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FEBRUARY 1961

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A Journal for All Science and Mathematics Teachers

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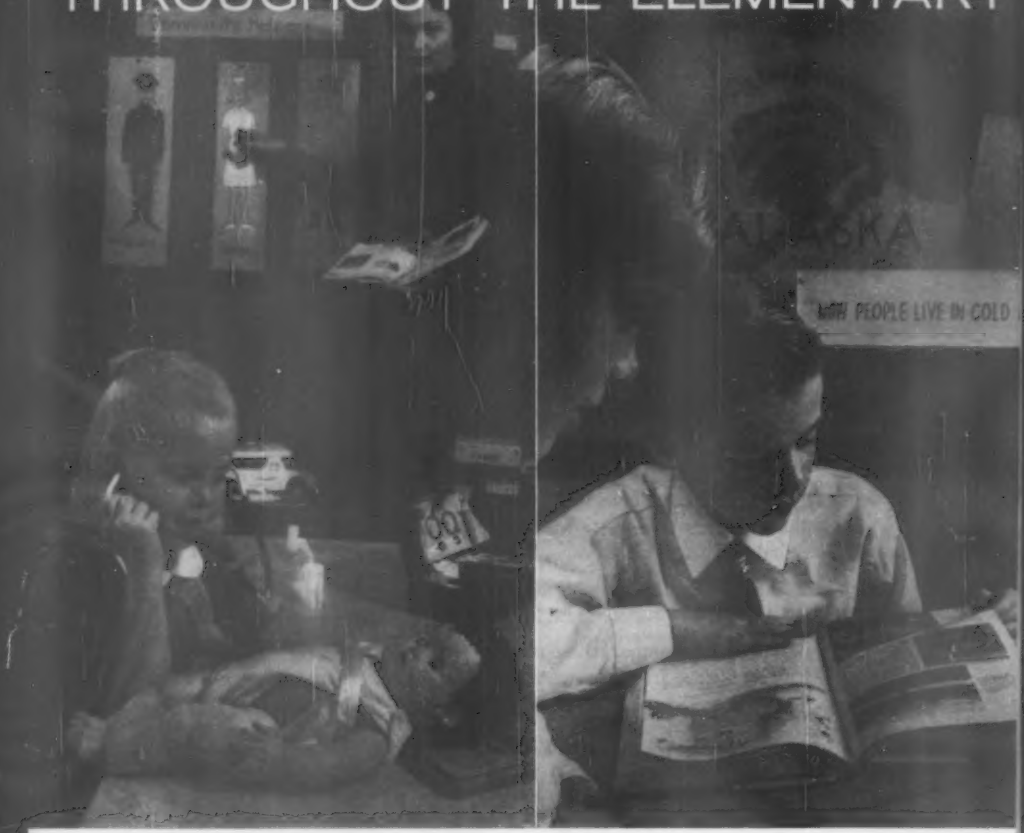

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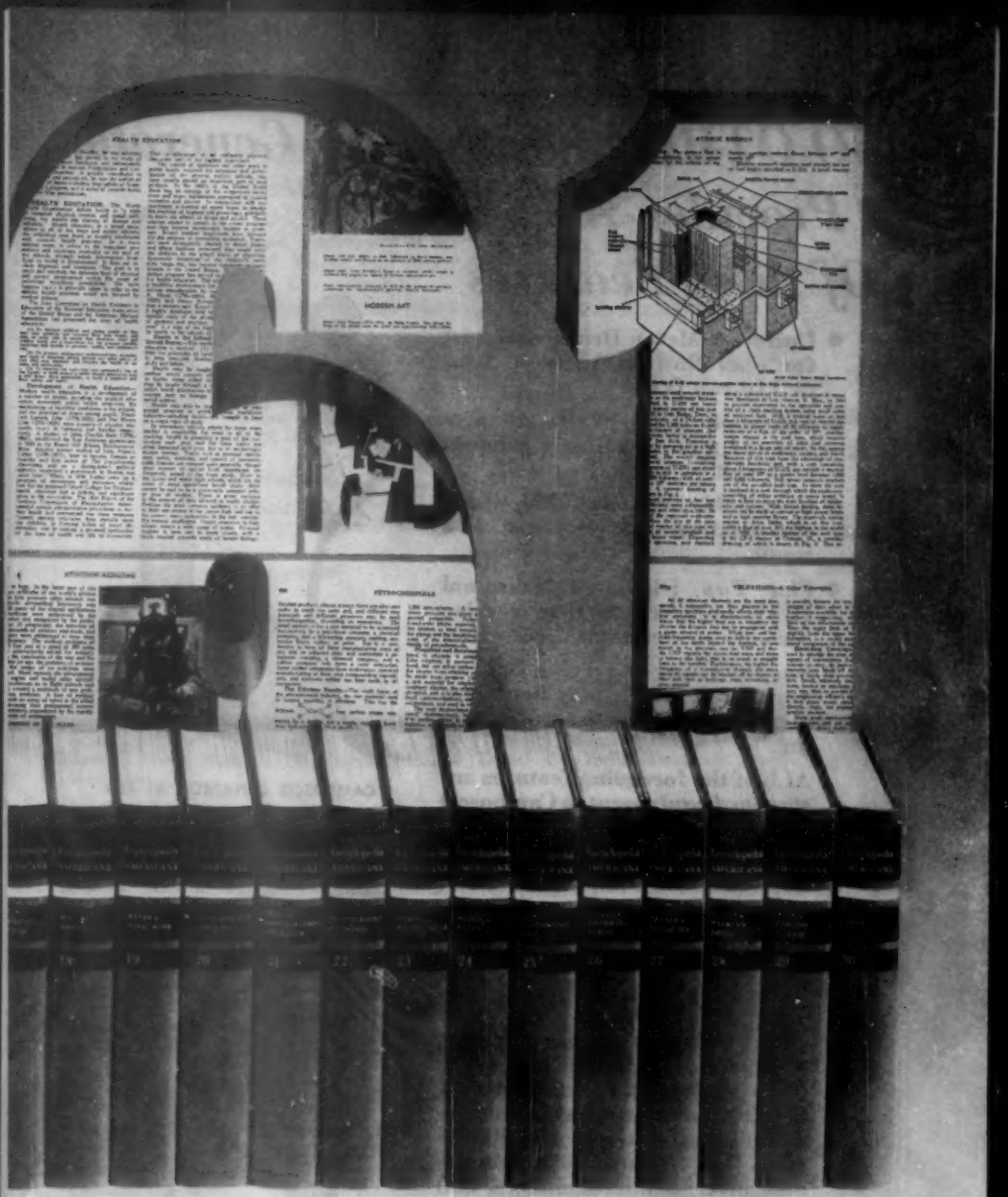

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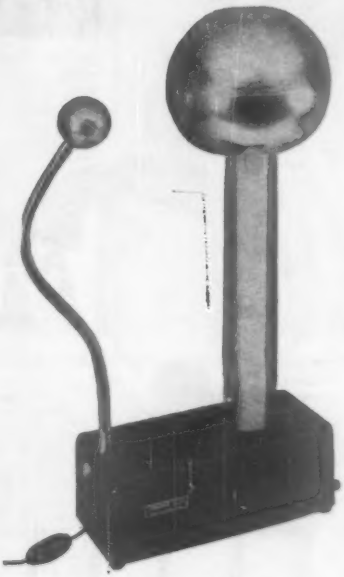

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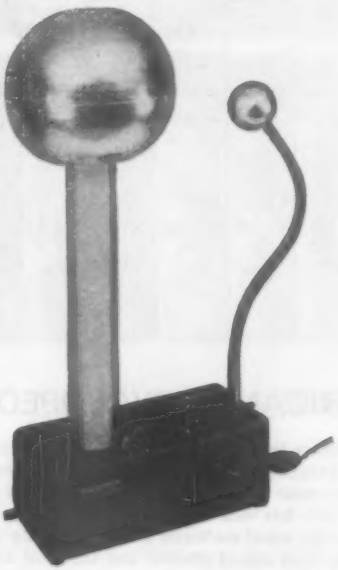

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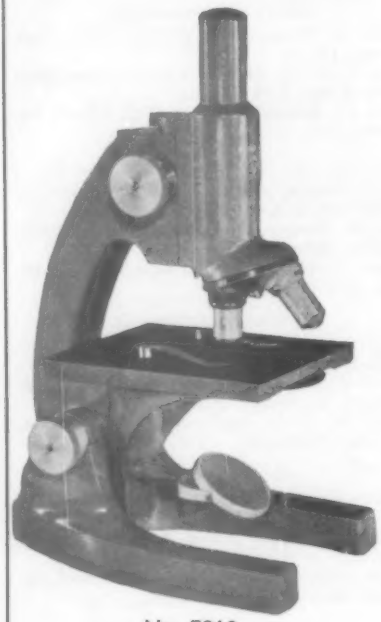

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VOL. LXI FEBRUARY, 1961 WHOLE NO. 535

Archimedes and His Sandreckoner

Cecil B. Read
University of Wichita, Wichita, Kansas

No doubt most teachers who have had a course in the history of mathematics, or who have done some reading in this field, vaguely recall that Archimedes is given the credit for a method by which he attempted to count the number of grains of sand in the entire universe. It may also be remembered that in the process he developed a number system by which he could express numbers which even today we consider extremely large, even in comparison with the national debt or the monthly grocery bill.

However, beyond one form or another of these somewhat brief statements, one usually finds little more in the usual books on the history of mathematics. Yet there is, if one delves deeper into this little treatise of Archimedes, something of far more than passing interest. *The Sandreckoner* almost deserves a place by itself. In all probability it is a mere arithmetical curiosity; there is little to warrant the hypothesis advanced by one authority to the effect that Archimedes had and made some use of a symbolism based on the decimal system or a variant thereof. But even as a mathematical curiosity, it illustrates the versatility and genius of Archimedes. Moreover, and of no little importance, we find an interesting sidelight on one Greek concept of the solar system, contradicting statements often made that not until some 1800 years later did the theory arise that the center of our system might be the sun, and not the earth.

Perhaps it is worth while to quote extracts from the preface, which was addressed to King Gelon of Syracuse:

There are some, king Gelon, who think that the number of the sand is infinite in multitude; and I mean by the sand not only that which exists about Syracuse and the rest of Sicily but also that which is found in every region whether inhabited or uninhabited. Again there are some, who, without regarding it as infinite, yet think that no number has been named which is great enough to exceed its multitude. . . . But I will try to show you by means of geometrical proofs which you will be able to follow, that, of the numbers named by me and given in the work which I sent to Zeuxippus, some exceed not only the number of the mass of sand equal in magnitude to the earth . . . but also that of a mass equal in magnitude to the universe. Now you are aware that "universe" is the name given by most astronomers to the sphere whose center is the center of the earth and whose radius is equal to the straight line between the center of the sun and the center of the earth. This is the common account. . . . But Aristarchus of Samos' . . . hypotheses are that the fixed stars and the sun remain unmoved, that the earth revolves about the sun in the circumference of a circle, the sun lying in the middle of the orbit . . .

Here is clear cut evidence that this Greek—Aristarchus of Samos (about 310–230 BC) had anticipated Copernicus. In fact, if we replace "circle" by "ellipse" we have essentially our modern concept.

Archimedes then goes on to point out that Aristarchus assumed the size of the earth to be negligible in comparison with the tremendous size of the universe. This assumption is not suitable for Archimedes' purpose, for he must assume some definite size, however large, for the diameter or for the radius of the universe. More than this, he must assume certain dimensions for the earth, the moon, and the sun. He must estimate the angle subtended at the earth by the diameter of the sun. If his estimates should be in error, he, to be sure he has accomplished his objective, must have the error in the proper direction.

Thus Archimedes proceeds to make certain assumptions, for example, a value for the circumference of the earth; he assumes that the diameter of the earth exceeds the diameter of the moon, and that the diameter of the sun exceeds the diameter of the earth. Moreover he assumes that the diameter of the sun is about 30 times the diameter of the moon. Certain other assumptions are somewhat intriguing. If a quantity of sand is taken not greater than a poppy seed, it is supposed to contain not more than 10,000 grains; the diameter of a poppy seed is assumed to be not less than 1/40th of a finger breadth.

With these and a few other assumptions, Archimedes is now ready to carry out the calculations necessary for his problem, but the Greek alphabetic system of numerals is inadequate to express numbers of the size required. Archimedes' reasoning proceeds somewhat as follows:

> Traditional names exist for numbers up to a myriad, or 10,000; we can therefore express numbers up to a myriad myriads. He calls these numbers of the first order. This includes numbers up to 100,000,000.
>
> Suppose the 100,000,000 to be the unit of the second order, then

the second order will consist of the numbers from that unit up to $(100,000,000)^2$.

Take this as the unit of the third order, and let it consist of the numbers from that unit up to $(100,000,000)^3$.

Following in this manner, we eventually reach the 100,000,000th order of numbers, which will end with the number $(100,000,000)^{100,000,000}$ which may be called P.

In modern notation, numbers of the first order are those up to 10^8, those of the second order are those from 10^8 to $(10^8)^2$ or 10^{16}, etc., those of the (10^8)th order end with the number $P=(10^8)^{10^8}$.

Archimedes now supposes the numbers just described (from 1 to P) form the first period. If P be the unit of the first order of the second period, this will consist of numbers from P to $100,000,000P$.

The second order of the second period has this last number as its unit, and ends with $(100,000,000)^2P$. Going on in this manner, eventually one reaches the 100,000,000th order of the second period, or $(100,000,000)^{100,000,000}P$, or P^2.

Taking P^2 as the unit of the first order of the third period, it is possible to proceed until we reach the 100,000,000th order of the third period, ending with P^3. Continuation of the process lets one eventually arrive at the 100,000,000th order of the 100,000,000th period or P^{10^8}. This is the number called by Archimedes "a myriad-myriad units of the myriad-myriad-th order of the myriad-myriad-th period."

The magnitude of the system is indicated if we consider that the last number of the first period would, in our decimal notation, be represented by 1 followed by 800,000,000 ciphers.

It is of interest to note that to express "the number of the sand" Archimedes needs to go no further than the eighth order of the first period. For those interested in more of the details, a partial translation and a summary may be found in Heath, T. L., *The Works of Archimedes* (Dover Publications, New York) or in Volume 1 of Newman, James R., *The World of Mathematics* (Simon and Schuster, New York). These two seem to be identical. The author of this article seems to recall at one time having in his hands a small volume which was a complete translation of *The Sandreckoner*. However, at the present time he is unable to locate either the book, or any record of its having been published.

As was stated earlier, this work by Archimedes is of value as a mathematical curiosity which demonstrates that men of the capability of Archimedes refused to be limited by the handicaps of the Greek alphabetic number system. The system herein developed is

adequate for numbers of any size likely to be encountered. But of perhaps even greater value is the reference to an hypothesis which seems startling when encountered as early as the third century BC—namely, that the sun, not the earth, is at the center of our universe. We regret deeply that Archimedes, a younger contemporary of Aristarchus, did not tell us more about this hypothesis. The only book of Aristarchus which has been preserved is a treatise: On the dimensions and distances of the sun and the moon. This contains no mention of any hypothesis on the planetary system. However, two brief references by other writers include the hypothesis, including, in the case of a reference by Plutarch, the inclusion of the rotation of the earth on its axis.

As is frequently the case, a study of work in one field yields, almost as a side issue, material of equal if not greater importance in a related field.

EUROPEAN TRAVEL STUDY PROGRAM IN COMPARATIVE EDUCATION

Wayne State University's College of Education and Graduate Division again approve credit arrangements in connection with the 14th Annual European Travel Study Program in Comparative Eeucation. Personally directed by Dr. Wm. Reitz, Professor of Education, the group will leave Detroit on June 24 and return on September 1, 1961.

Visiting 13 countries during the 10 weeks' journey, this program is designed to provide teachers, students, and other professional people with opportunities to survey selected highlights of the life and culture of Western Europe. There are approximately 425 alumni of past programs.

Persons may qualify to earn from 2 to 6 hours of graduate or undergraduate credit—to apply on degree programs, for teaching certification, or for annual salary increments. Others may register for "audit" credit and participate in the program for purposes of personal or professional enrichment.

Arrangements will be offered on two price levels: (1) regular *first class* program; and (2) *economy* program. All-inclusive land and cruise costs for the first class program are about $1535 and, for the economy program (without cruise), $940—plus in either class, the Trans-Atlantic roundtrip air fare.

Special highlights of the 1961 program include an Adriatic and Aegean cruise visiting ports of Greece and Turkey: Corfu, Athens, Mykonos, Delos, Istanbul, Bosphorus, Troy, Rhodes, Crete, Delphi, Nauplia, and Brindisi.

Further information may be obtained from Dr. Wm. Reitz, College of Education, Wayne State University, Detroit, 2, Michigan.

The University of Michigan has received word from the National Science Foundation that an Academic Year Institute will be supported for high school teachers of chemistry, mathematics, and physics during the year 1961–62. Information regarding the Institute can be obtained from

Professor L. C. Anderson, Director
1018 Angell Hall
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A Pilot Study of Team Teaching in an Extra-Curricular Science Seminar*

William A. Hill, Chairman

Science Department, Naperville Community High School, Naperville, Illinois

A backdrop of information about Naperville and its environs should be of help in evaluating the program. I shall attempt to describe.

Naperville, with a population of about 12,000 is located about 30 miles southwest of Chicago. A western projection of 63rd street in Chicago would pass through our town. Like most suburbs, Naperville is in a state of growth—though not as rapid or dramatic as has been the case in some northwestern suburbs.

The high school has an enrollment of about 1000 students. Its curriculum presently provides 5 years of math and four years of science. Approximately 80% of our graduates enter college. The school day is divided into eight 53 minute periods, and at present, every room in the school is being utilized each period of the day.

The Naperville Community High School Science Seminar program for the talented science students was organized during the 1958–59 school year. A number of highly qualified local citizens expressed interest in the establishment of an extra-curricular science program similar in some respects to that proposed by the Joe Berg Foundation. This group of citizens met with the teaching staff, and offered both time and service in this program. It was immediately evident that these lay citizens felt an enthusiastic desire to participate in the public education scheme, and yet, harbored no feelings of criticism or antagonism for or about our school's curriculum or staff.

Several decisions were reached concerning this program almost immediately:

1. The students to be involved must be carefully selected from the top ranking scholars.
2. The students must feel a desire to learn above and beyond the call of duty in their respective classes.
3. The evening meetings shall be as informal as possible, and patterned after the collegiate seminar meeting.

The seminar meeting framework and the original format of the individual meeting were based on the assumption that a majority of those local residents who were engaged in scientific research, or in advanced science education would cooperate with the program.

The original advisory committee served very emphatic notice that this extra-curricular activity should at no time become involved with

* Paper presented to the Chicago Section of the American Association of Physics Teachers meeting at Evanston Township High School, Evanston, Illinois, on November 19, 1960.

any goal or objective related to the production of student's science projects. This opinion has been emphatically restated in subsequent meetings of advisory groups, and often expressed by individual adult seminar discussion leaders.

What could be the stated purpose of this manner of activity? For two years the program was operated with weekly meetings devoted to a two-fold purpose:

1. To augment the science department's endeavors to keep our students alert and fully informed as possible about current science problems and research programs.
2. To motivate interest in advanced science study by making science research vivid in terms of each of the discussion leaders' personal experience.

The following recommended format for the individual seminar meeting will best indicate the approach and aim of the program in its first two exploratory years.

I. Educational biography.
   A. To illustrate the total educational investment involved.
   B. To illustrate the diversity of subjects required for a single major.
   C. To illustrate the influences leading to specific field selection.
II. Problem Studied.
   A. Follow thread of interest that led to problem studied, or under study.
   B. Move from the personal to objective.
III. Problem Framework.
   A. Provide framework of problem in the field.
   B. Provide some description of field content.
   C. Demonstrate *that a detail is significant.*
IV. Precision significance.
   A. Provide evidence that precision is required.
   B. Demonstrate some problems in attaining precision.
V. Method of attack.
   (Our only recommendation under this title is that the speaker be forthright in admitting significance of hunches, analogies, etc.)
VI. Conduct of Work.
   A. Data accumulation.
   B. Reduction of data.
VII. Results of Work.
   A. Degree to which original goal was attained.
   B. New researches suggested.
   C. New inconsistencies developed, if any.
   D. Comparison with other researches.
VIII. Impact on Field.
IX. Publication, if any.

Time for presentation: One and one-half hours. A half hour question period should follow the presentation.

During the first two years of the science seminar program speakers and discussion leaders were always in greater abundance than time and open evenings. The research programs included ranged from that outlined in the thesis, "Physiological Data at High Altitudes" to "Rare Earths" to "Stress in Pre-stressed Concrete."

In each topic the students were able to experience a move from a hunch or guess to the objective accumulation of data.

In the 1960–61 seminar series a more formal sequential series of topics forms what, in effect, amounts to an extra-curricular, non-credit course in Nuclear Radiation Physics. A team of sixteen highly qualified physicists is engaged in the presentation of twenty-two topics. Each week one of these volunteers presents the framework of his topic, and then proceeds to answer questions and lead a discussion of the topic—its relation to previously covered topics, and to subsequent topics.

The topical outline is as follows:

September 19	Quantum Nature of Electromagnetic Radiation by Dr. Henry A. Kierstead, Argonne National Laboratory
September 26	Wave Properties of Particles by Dr. Paul J. Persiani, Argonne National Laboratory
October 3	Atomic Structure by Dr. Charles M. Huddleston, Argonne National Laboratory
October 10	The Pauli Principle and Subsequent Concepts by Dr. Verne E. Dietrich, North Central College
October 17	Isotopes and Nuclear Structure by Dr. Peter A. Moldauer, Argonne National Laboratory
October 24	Radioactive Transformations by Dr. Andrew F. Stehney, Argonne National Laboratory
October 31	X-Rays and Gamma Rays by Dr. Paul J. Persiani, Argonne National Laboratory
November 14	The Mössbauer Effect by Dr. Juergen Heberle, Argonne National Laboratory
November 21	Alpha Particles by Dr. Richard S. Preston, Argonne National Laboratory
November 28	Beta Particles by Dr. Peter A. Moldauer, Argonne National Laboratory
December 5	Particle Accelerators by Dr. Richard S. Preston, Argonne National Laboratory
December 12	Induced Nuclear Transformations by Dr. Andrew F. Stehney, Argonne National Laboratory
December 19	The Neutron by Dr. Norman J. Frigerio, Argonne National Laboratory
January 9	Neutron Activation by Dr. Norman J. Frigerio, Argonne National Laboratory
January 16	Neutron Detection by Dr. George Thomas, Argonne National Laboratory
January 23	Nuclear Fission and Power by Dr. Bernard I. Spinrad, Argonne National Laboratory
January 30	Radiation Measurement Techniques by Mr. Robert Dvorak, National Laboratory
February 6	Biological Effects of Radiation I by Dr. E. Lawrence Powers, Argonne National Laboratory
February 13	Biological Effects of Radiation II by Dr. Edward W. Daniels, Argonne National Laboratory
February 27	Radioactive Tracer Techniques by Dr. Robert K. Steunenberg, Argonne National Laboratory
March 6	Excursions and Explosions In Nuclear Science by Dr. Bernard I. Spinrad, Argonne National Laboratory

March 20 Radiation Safety by Mr. Keith Schiager, Argonne National Laboratory

This outline of topics is based primarily on Lapp and Andrews, "Nuclear Radiation Physics." Copies of this text and others are available to seminar participants through both the school library and the science department library.

Student preparation for active participation in the seminar discussion has been a key point in the current series. Some discussion leaders have provided, in advance of the date of their presentation, copies of books, magazines, abstracts or photostats of portions of research papers—each to be distributed among the students prior to the scheduled seminar. At least one-third of the student participants have purchased a copy of one of the recommended references, and read the recommended sections carefully. The student response in terms of regular attendance, and in terms of active participation has been gratifying to all concerned.

In conclusion, what is our tentative evaluation of this pilot study in this medium-sized high school in the far-western suburbs? This question can first be answered by another question. What high school of our size could normally offer our most capable science students a teaching team equivalent to our 1960–61 seminar team? Sixteen teachers, each equipped with a doctorate in his field—or in the process of completing this advanced degree.

A second conclusion is related strangely to a question too often raised by those who constantly advise teachers-in-training to register for endless courses in education rather than subject matter courses. These "advisors" would shudder at seminars conducted by people with little or no background of experience in secondary school pedagogical technique (if such a thing exists). It has been our observation that the student participants appreciate clear explanations or answers to their questions, but are motivated to study and discuss intensely those topics that the discussion leader failed to clarify—or explain in terms beyond their immediate capacity to understand. In short, the students appreciate a teacher keenly trained in his subject field, even if his sensitivity to their level of understanding is not equally keen. It has been my privilege to participate in the seminars, and in endless bull-sessions following each seminar meeting. I cannot ever recall a group of high school students as mature in their goal of self-education as our present seminar participants. They read because they want to learn. They discuss to help themselves understand. They come to staff members with questions we often cannot answer—yet, not once have we lost rapport with our group. The impact of this mature approach to an education has been felt throughout our school—in English classes, in Social Science classes. A team has performed a remarkable educational task—one that is beyond the power and scope of any single secondary school teacher.

Coordinate Systems and Explanations in Mechanics[1]

Albert F. Eiss

Department of Public Instruction, Harrisburg, Pennsylvania

During most of the history of the human race, man has moved about in a two-dimensional world. He has always been aware of the third dimension, but he was not able to travel in it extensively until the beginning of the present century. When he probed into this third dimension he began to suspect new problems. As he extended his explorations of the third dimension into the vastness of space he was brought face to face with the fact that many of the explanations of phenomena that served his limited two-dimensional outlook in the past were not valid in the extended region of three dimensional space.

He had developed suitable explanations that seemed to account for all the aspects of the behavior of matter. When conditions demanded a more searching analysis, it developed that the explanations were not as all-inclusive as he has supposed. In some cases different phenomena were given identical explanations; in other instances the same principle was explained in different ways. This was first pointed out by Einstein and Infield in *The Evolution of Physics*.[2] Unfortunately, this point has been largely disregarded because the problem did not become serious until the production of greatly increased velocities in recent years.

A careful analysis of the different types of explanations given to various phenomena related to inertia and acceleration shows that the observer's coordinate system of reference will affect his description of the event. The more common types of coordinate systems used in mathematics are the Cartesian, the polar, and the spherical polar. Since we are more accustomed to thinking in terms of the Cartesian system, and since other systems may be expressed in terms of this system, the Cartesian system of reference will be used in this discussion.

The difficulties encountered in explaining many mechanical phenomena in three dimensional space are due to the fact that an explanation that is correct for one reference system under certain conditions may not be correct for another.

In observing our environment and interpreting various events, several types of Cartesian coordinate systems are used, as shown in Figure 1. With respect to a given point, a Cartesian coordinate system may be fixed, it may be moving, or it may rotate about one or both axes. A system with its axes fixed with respect to a given point

[1] A paper presented at the Section Q meeting of the American Association for the Advancement of Science at Chicago, Illinois, December 29, 1959.

[2] Einstein, Albert, and Infeld, Leopold, *The Evolution of Physics*, New York: Simon and Schuster, 1938, p. 160 ff.

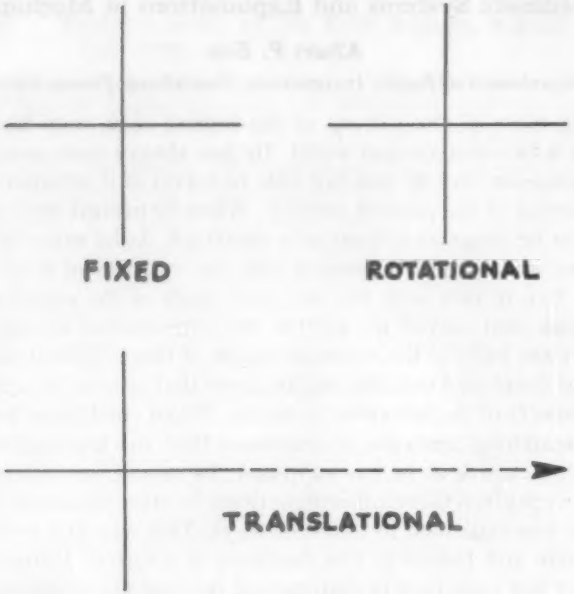

FIG. 1. Common types of Cartesian coordinate systems.

on the earth's surface is commonly used. Another common system is rotational, with its origin at the center of the earth. Another has its origin at the center of the earth and its axes fixed with respect to the sun. Probably the most commonly used system is fixed with respect to the individual observer. It is at rest when he is standing still, it moves when he moves, and rotates when he turns. As long as the observer remains on the surface of the earth, this system is oriented with respect to its vertical, but not its horizontal axis. That is, an individual observer with his eyes closed, eliminating any visible reference points, is conscious of up and down, but not the points of the compass.

There is a marked tendency of an observer in motion to interpret an event in terms of his individual coordinate system. Almost every person has had the experience of looking out of a slowly moving train window and feeling the sensation of sitting still while the station moves slowly by the window. It may be facetious, but it is quite apparent when you suddenly descend in an elevator, that the origin of this individual coordinate system is located in the pit of the stomach.

Most of the confusion arising from explanations in mechanics arises from a failure to specify the coordinate system from which the event is described. Because the system is not identified, it is often impossible to label a given explanation as "correct" or "incorrect."

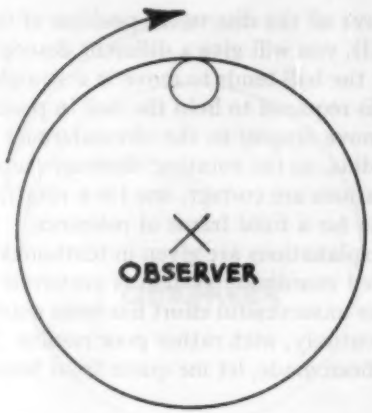

FIG. 2. Rotational.

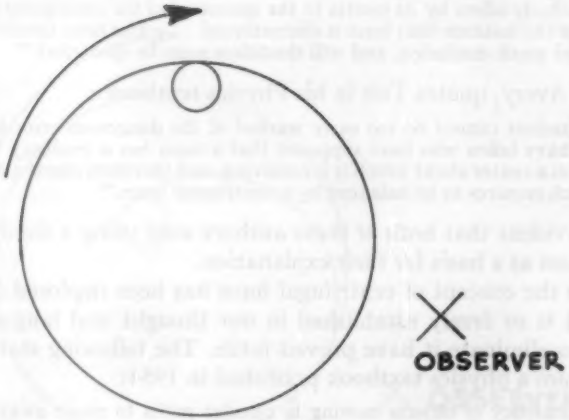

FIG. 3. Inertial.

As an example of different explanations that may be given to observed phenomena, let us consider a smooth ball resting on a rotating metal disc. Imagine yourself at the center of the disc, with the ball placed at the edge of the disc (Figure 2). A force will be required to hold the ball on the disc while the disc is rotating. If the ball is released, it will fly away from you in a straight line, parallel to a radius of the disc. (Remember, you are turning with the disc.) Apparently, there is a force, called centrifugal force, tending to force the ball outwards, and an equal force, called centripetal force, is required to hold the ball in position.

Now, if you move off the disc to the position of the observer at the point X (Figure 3), you will give a different description of the event. You will say that the ball tends to move in a straight line, and that a centripetal force is required to hold the ball in position. If the ball is released, it will move *tangent* to the circumference of the circle, not parallel to the radius, as the rotating observer stated. It is apparent that both explanations are correct, one for a rotating coordinate system, and the other for a fixed frame of reference.

Both of these explanations are given in textbooks, but the explanation using the fixed coordinate system is preferred by most authors. For many years an unsuccessful effort has been made to eliminate the first explanation entirely, with rather poor results. To show how long this attempt has been made, let me quote from Steele's *Physics*, published in 1879.

"It should be noted that in circular motion there is but one true force concerned. It acts, however, upon a body in motion. The so-called centrifugal force has nothing to do with the production of the motion, being merely the resistance which the body offers by its inertia to the operation of the centripetal force, and and ceases the instance that force is discontinued. . . . The term centrifugal force has caused much confusion, and will doubtless soon be discarded."[3]

In 1895 Avery, quotes Tait in his Physics textbook:

"The student cannot be too early warned of the dangerous error into which so many have fallen who have supposed that a mass has a tendency to fly outwards from a center about which it is revolving, and therefore exerts a centrifugal force which requires to be balanced by a centripetal force."[4]

It is evident that both of these authors were using a fixed, or inertial system as a basis for their explanation.

While the concept of centrifugal force has been deplored for many years, it is so firmly established in our thought and language that efforts to eliminate it have proved futile. The following statement is taken from a physics textbook published in 1954:

"The tendency of objects moving in circular paths to move away from the center of their motion is called *centrifugal force*. . . . Water in a bucket may be whirled over one's head and held in the bucket by means of centrifugal force which is greater than the force of gravity acting on the water."[5]

Most geology books explain the motion of a satellite by using a coordinate system having its origin at the center of the earth, and one axis turning at the angular velocity of the satellite's motion. In a book published in 1959, the author went so far as to state:

To remain in orbit, the speed of the artificial moon must be exactly sufficient to provide enough outward pull, called *centrifugal force*, to balance the gravitational pull of the earth.[6]

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[3] Steele, J. D., *Fourteen Weeks in Physics*, New York: A. E. Barnes and Company, 1879, pp. 33–34, footnote.
[4] Avery, E. M., *School Physics*, New York: American Book Co., 1895, p. 78.
[5] Burns, *et al.*, *Physics*, New York: D. Van Nostrand Co., 1954, p. 101.
[6] Finch, *et al.*, *The Earth and Its Resources*, New York: McGraw-Hill Book Co., 1959, pp. 1–2.

FIG. 4. Rotational

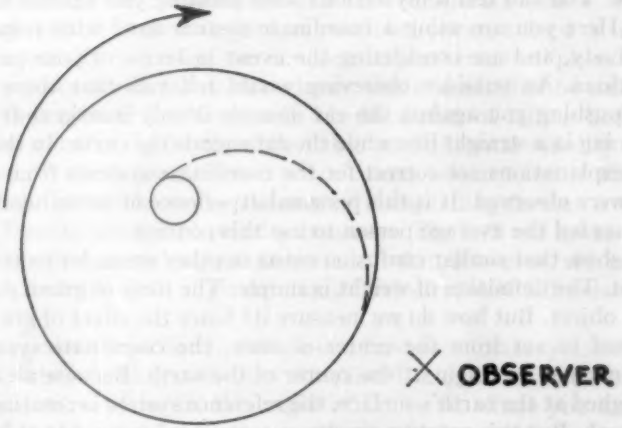

FIG. 5. Inertial.

It would appear that the concept of centrifugal force is so deeply ingrained in our thinking and teaching that is behooves us to explain the concept rather than avoid the issue.

Now, let's take another ride on the disc and observe the behavior of the ball under different conditions. This time we will place the ball near the center of the disc while the system is at rest. Then we will start the disc turning, producing an angular acceleration (Figure 4). If we observe the ball while standing at the center of the disc, we will find that the ball appears to curve in a direction opposite to the direc-

tion of rotation. An outside observer would tell us that the ball appears to curve in a direction opposite to the disc's motion. We can use the concept of centrifugal force to explain the ball's outward motion, but we still have to invent another force to explain its curved path.

We will be really surprised to observe the event from the outside observer's position at the point X (Figure 5), because the ball will appear to curve in the *same* direction as the disc's rotation: The only phenonomenon on which both observers would agree is that the ball itself rotates in a counter-clockwise direction as it accelerated.

This illustration shows that the greatest objection to the use of a rotating coordinate system (unless the observer is aware that it is rotating) is that several imaginary forces must be invented to explain the motion of the ball. In an inertial system, the only force that must be postulated is inertia. It has always been an axiom of science that, other things being equal, the simplest explanation is preferred.

If you wonder why the concept of centrifugal force was invented in the first place, consider your sensation in rounding a curve in an automobile. You can feel a mysterious force pushing you against the car door. Here you are using a coordinate system fixed with respect to your body, and are considering the event in terms of your personal sensations. An outsider observing would tell you that there is no force pushing you against the car door; it is only inertia that keeps you going in a straight line while the car rounds the curve. In this case both explanations are correct for the coordinate systems from which they were observed. It is this personal experience of centrifugal force that has led the average person to use this concept.

To show that similar confusion exists in other areas, let us consider weight. The definition of weight is simple: The force of gravity acting on an object. But how do we measure it? Since the effect of gravity is assumed to act from the center of mass, the coordinate system of reference has its origin at the center of the earth. Because an object is weighed at the earth's surface, the reference system is rotating with the earth. But this rotation produces centrifugal force. (At this point it's simpler to use this concept than the concept of inertia.) Therefore the object being weighed is a little lighter due to the earth's rotation. Then, too, there is the buoyant effect of the air. Our only solution for getting the true weight of an object is to take it to the North Pole and weigh it in a vacuum. We must use a spring scale: a beam balance will give us the relative weight, which would be the same as the equator, at the Pole, or, for that matter, on the moon.

Neither method of weighing would work on a space ship, yet, according to our definition, an object has weight as long as it is in a gravitational field. It appears that the weight of an object cannot be determined unless we can measure it at rest with respect to the mas-

sive body producing the gravitational field, and then the value may be only approximate.

Looked at in this light, the classical definition of weight seems a little ridiculous, and we are more inclined to use the operational definition, which is the degree of extension of a spring scale. Using this concept, we place origin of the coordinate system at the center of the object to be weighed, and measure the degree to which the mutual attraction of the two bodies will produce an extension of a spring scale. This is a more relative definition, and it is one that is oriented to our individual coordinate system. An individual who is experiencing weightlessness during free fall through space is not helped by being told that he actually has weight, but that it can't be measured unless he comes down to earth. No amount of reasoning can remove the sinking feeling in the pit of his stomach; he may learn to adapt himself to it, but the sensation will continue to exist. This tendency to interpret phenomena by reference to personal sensations seems so firmly established that no amount of scientific argument can change it.

To return to the consideration of a fixed coordinate system, we may conclude that it is used as often as possible because a fixed or inertial system usually provides the simplest explanations of phenomena. Most physics textbooks explain the motion of a satellite by using the method suggested by Newton in his discussion of falling bodies. If we drop a ball (Figure 6), while it has no horizontal velocity it will fall directly downward. Give it a horizontal velocity and it will take one of the paths shown by the dotted lines, falling farther from the point P as its horizontal velocity increases. The ball will never fail to strike the ground as long as the surface is flat. However, the earth is curved, and the ball, if given enough velocity, will fall *around* the earth.

The greatest objection to the use of a fixed coordinate system is that an absolutely fixed system does not exist. Let us attempt to describe such a system. If we fix the origin at the point where you are now located, we must consider the earth's revolution on its axis, and its rotation around the sun. If we fix the origin of the system on the sun, we find that it is moving through space in the direction of the constellation Hercules. If we attempt to fix the system with respect to space, we find that the concept is meaningless. The nearest approach to a truly fixed coordinate system is one with its axis fixed with respect to the so-called "fixed" stars. This concept is of no value to anyone except an astronomer. As a result, we usually use an inertial system, which may be moving through space at any velocity, as long as it is not accelerating or rotating.

Regardless of the various coordinate systems used in explaining phenomena, we must always return to the system that we carry about

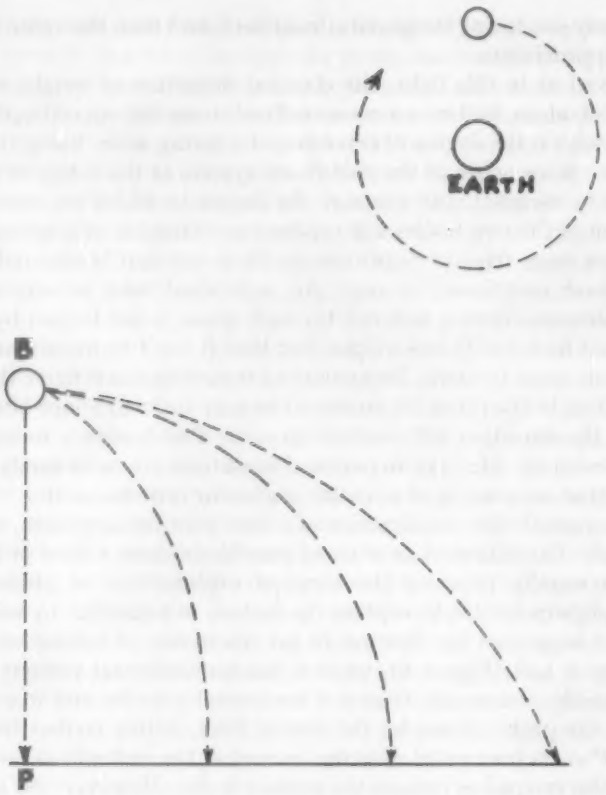

FIG. 6

with us. Everything eventually must be interpreted in terms of this system. Most people do not realize that this is true until they begin to consider space travel. In order to study man's reaction to the weightless conditions that will exist in space travel, scientists have used two ways of simulating space travel: accelerating or rotating man's reference systems. Studying the effects of free fall by delaying the opening of the parachute during the first part of a jump and by the use of the "outside loop" in a plane, scientists have been able to duplicate for a few seconds the sensation to which man will have to accustom himself over long periods of time. Before any long-term study of the effects of weightlessness can be made, scientists must wait until they can actually orbit a man in space. In the final analysis, it may not be physical laws, but man's personal sensations that will create the most difficult problems in space travel.

It is evident that many explanations of phenomena of moving objects vary with the coordinate system used for reference. This is an important concept to introduce into the study of objects in motion. It is an area in which mathematical concepts can be intergrated with physical concepts to their mutal advantage. Unfortunately, most physics textbook authors have avoided any mention of coordinate systems, and choose to give some of their explanations from one frame to reference, and some from another, without specifying the coordinate system used. Failure to do this gives rise to a great deal of confusion and arguments about which explanations are "right" and which are "wrong."

It would appear that explanations of moving objects would be much more logical and more easily comprehended if instructors would instill in student's minds a clear recognition of the existence of several coordinate systems, and the conscious use or application of the coordinate system that best fits the particular problem.

POWER FROM UNDERGROUND HYDROGEN BOMBS

Low-cost energy may be provided by harnessing steam produced by underground explosion of hydrogen bombs. This plan is attributed to Dr. Edward Teller, "father of the hydrogen bomb." Other suggestions for peaceful uses of underground nuclear bomb explosions made by Dr. Teller included: moving earth to make artificial harbors; underground chemical factories which would change the characteristics of minerals and other materials; creating underground reservoirs for flood waters; and open-pit strip-mining to depths of from 500 to 700 feet, possibly for oil shales or oil sands.

PEOPLE WILL LIVE LONGER, FISHBEIN PREDICTS

A generation from now, doctors will be keeping grandpa literally young at heart.

By controlling the body's enzyme systems, doctors will help a patient stave off degeneration and aging of the heart, blood vessels and endocrine glands, and many will be going strong at 80 years of age.

It is expected that the next generation's physicians will see a population in which 20% are past age 65 and 2% are past 100.

The noun "cripple," will probably drop out of the language as new techniques in training the physically handicapped are perfected.

Mental retardation which now affiicts approximately three percent of the population will tend to disappear as new processes of learning are applied to child training.

Infectious diseases such as measles, scarlet fever, whooping cough, mumps, diphtheria, respiratory disorders and polio will be virtually eliminated from the American scene.

However, it is warned, physicians will have to combat "flash epidemics" of imported infections so long as these diseases exist elsewhere in the world. Our own population will lack the immunities which older generations acquired by casual exposure and will be extraordinarily susceptible.

Demonstrate and Teach

Willis Swales, Jr.
Summit High School, Summit, New Jersey

An ancient philospher has said, "One picture is worth a thousand words." By implication, if the picture and words were both there then the importance of the event would be more clearly seen, more easily explained, and more readily understood.

To many science teachers memorizing a law, talking about a principle, and solving a problem are all with which they feel a need to be concerned. Their courses are generally boring to the student, and all that is learned is that which is needed for the immediate test.

If those same teachers were to demonstrate along with their talk, how much more meaningful and interesting their course would be!

A good science teacher, whether teaching physics, chemistry, biology, general science or any high school or grade school science, should be a good demonstrator for several reasons:

1. Science texts will not do all the teaching.
2. A good demonstration will shorten the time for learning and lengthen the memory of facts and principles.
3. An effective demonstration can do much to foster good thinking both of groups or of individuals.

The good teacher, or demonstrator, should of course realize that demonstration is only one of the excellent ways in which good science instruction can be accomplished. He will only demonstrate where appropriate. The demonstration will never be used as a substitute, nor will it eliminate other teaching methods.

The demonstration can open a students eyes to a new world of understanding and logic. He can see scientific method and evaluation on one hand, and draw conclusions and absolute knowledge on the other.

A science teacher can easily say, "This is so." But that does not mean that he will be understood. With the demonstration the teacher may say, "See, this is what happens." He may say, "By doing this I may benefit all who learn from me. I will *tell* you that this is so. I will *show* you that it is so. You will *see* that it is so!"

The following suggestions should aid a teacher in becoming a demonstrator, or in giving a demonstration lesson:

1. Be sure that you are familiar with the demonstration. Go over it at least once prior to showing it to the class. In other words, rehearse it.

2. Explain the problem to the class beforehand. An understanding of what will happen will help in solving the problem later, and in the

writing of the demonstration. After explanations, allow the students to make observations.

3. Be sure that the demonstration is visible to all of the students. Many classrooms are laid out in a way that this is difficult. A different seating arrangement might help.

4. Keep the attention of the students focussed on the demonstration table or close to it in the room. The background can be important, so a white surface, or if possible a black surface, should be used.

5. Use large size demonstration apparatus whenever possible. The advantage of this large size over small size is that attention will be further drawn to it. If large equipment is not available, small equipment is far better than no demonstration.

6. Allow students to help with the demonstration, if possible. Do not use the same students constantly, but choose different ones. This will lend interest to the experiment.

7. Never dictate conclusions of the experiment. A student's writing his own conclusions is a test of how effective your demonstration has been.

If a demonstration fails, the reason should be sought. This might be due to one, or several, reasons. If the demonstration succeeds, it may be well to point out several of the most common reasons why that demonstration might fail. These are typical reasons:

1. The demonstrator was not ready. He may not have his apparatus out or set up. He may not have tried the demonstration to see whether it will work. The solution to this failure would be to always rehearse the experiment before class time.

2. The demonstrator does not give enough time during the demonstration for recording data. A hurried experiment may do harm in moving too fast for a student to grasp an essential point. The ideal situation is to have enough time to repeat the demonstration, and make sure that the students have written the descriptions and numbers necessary to evaluate the experiment properly.

3. Perhaps the most common reason for failure, but the reason least seen by the demonstrator, is his own domination of the demonstration. Students should be assigned to do specific parts of it, with considerable responsibility for their technique. In the case where a student is wrong, and no classmate has caught the error, then it would be permissible to offer correction. The class should have the opportunity to correct the mistake of their contemporary. Once the student has done his part, he should draw his own conclusions. His demonstration report is the proper place to evaluate his conclusions, for him to see his errors, or to hear praise for his good work.

4. Students often do not have their attention focussed on major facts. A lesson in each science course on picking out the pertinent facts

and applying them to the demonstration would be of value. These facts can also be used in the recall process. A critical analysis of the results, as well as unsolved problems, can be useful in later demonstrations.

Demonstrations are good teaching. A demonstration well planned and executed presents an easier, more pleasant, better understood science lesson. The time and effort could hardly be spent more profitably.

FAINTEST STAR FOUND IN SOUTHERN SKY

The faintest star known has been discovered. It is more than 2,000,000 times dimmer than the sun, invisible except on the most sensitive photographic plates.

The star, which is about 30 light years away, was discovered by Dr. W. J. Luyten of the University of Minnesota. A light year is approximately six million million miles. Closest star to the earth is Alpha Centauri, four and a third light years away.

Dr. Luyten reported to Harvard College Observatory here that the star is very red. It was found on a red photographic plate but was invisible on a blue plate of the same area of the sky, photographed as part of the Mt. Palomar-National Geographic Society sky survey. The star is estimated to be a dwarf star of 20.5 magnitude.

A star's color inidcates its temperature, and also of the elements present. Blue giant stars are the hottest and brightest, red stars are the coolest and dimmest. The sun, a yellow star, belongs between these two categories.

Astronomers do not know how small this star is, and they expect about a year will be needed to determine its size exactly. It is located in Pisces, the constellation of the fishes, which can be seen in the southern sky during the early evening.

Dim stars help astronomers relate brightness of stars to their masses.

ANTI-RADIATION CHEMICAL IS ARMY MEDICAL GOAL

Anti-radiation agents to increase chances for survival in the event of nuclear war are being sought by the U. S. Army's Medical Research and Development Command, two medical researchers from the Walter Reed Army Institute of Research reported.

A drug development program, similar to that under which antimalarials were developed, is underway to find an anti-radiation agent useful for protecting man against radiation injury.

About 1,500 compounds have been evaluated for possible antiradiation action, mainly by the U. S. Air Force Radiation Laboratory. Of this number, 56 of a specific chemical series were selected as having the best potential. The Army Anti-Radiation Drug Development Program has limited itself to this series.

The chemical mixtures most recently used in dogs are nonlethal, and a dog under their influence is able to walk around and do mild exercise, the Walter Reed researchers reported.

Dogs exposed to high levels of X-radiation, receiving the chemical protection, were provided with at least a 50% reduction in the amount of injury sustained by untreated control dogs. Chemicals were all given intravenously.

The scientists are not yet ready to administer these agents systemically to people, however. The reason is that, although the dogs have not died from the anti-radiation chemicals, they have suffered severe side reactions. One aim of the Army program of research is to eliminate these effects.

The present anti-radiation agents are effective by mouth in mice or dogs for only four to five hours. If perfected so that they may be taken safely in oral administration by man, they would prove useful as a protection to those entering an irradiated area.

A Guide for the Mathematics Books of the Traveling High School Science Library of the American Association for the Advancement of Science and the National Science Foundation*

Margaret F. Willerding
San Diego State College, San Diego, California

Introduction

This study guide is prepared for use with the mathematics books contained in the Traveling High School Science Library of the American Association for the Advancement of Science and the National Science Foundation.

This guide has been organized on the basis of the subject areas recommended for high school mathematics by the Commission on Mathematics in the 1959 Report of the Commission on Mathematics. The appropriate pages of each book have been listed under selected subject headings. In addition a review section provides a cross reference for use in the consideration of the collection of books. The review section also contains the comments and impressions of the reviewer as to the readability and adaptability of each book for grade and student levels.

These books were generally found to be above the level of ability of the average high school mathematics student. The gifted mathematics student should find many hours of instructive and stimulating materials in this collection.

It is highly recommended that all high school mathematics teachers read all of the books in this collection with care. The teacher will find the reading of these books rewarding in the consideration of new and old topics in mathematics.

Section I: Subject Guide

Book Code Numbers:

B-38: Bell, E. T., *Men of Mathematics.*
B-39: Infeld, Leopold, *Albert Einstein.*
B-40: Gamow, George, *One, Two, Three, . . . Infinity.*
D-81: Logsdon, Mayne, *A Mathematician Explains.*
D-82: Courant, Richard and Herbert Robbins, *What is Mathematics?*
D-83: Berkeley, Edmund and L. Wainwright, *Computers: Their Operations and Applications.*
D-84: Bakst, Aaron, *Mathematics: Its Magic and Mastery.*
E-115: Kline, Morris, *Mathematics in Western Culture.*
F-131: Williams, J. D., *The Compleat Strategyst.*

* The author was assisted in formulating this guide by Lawrence Carr, Arden Ewing, Allen Hansen, Charles Hugins, Rilla Jarrett, Neil Johnson, Ethel Kidd, Eugene Nelson, Eleanor Sass, Jeanne Sherry, and DeWaine Silker, Participants in the 1959–60 N.S.F. A.Y.I. at San Diego State College.

F-132: Hogben, L., *Mathematics for the Million.*
F-133: Friend, J. N., *Numbers: Fun and Facts.*
F-134: Lieber, L. R., *Toe Education of T. C. Mits.*
F-135: Dantzig, T., *Number: The Language of Science.*
F-136: Kasner, E. and J. Newman, *Mathematics and the Imagination.*
F-147: Meyer, J. S., *Fun with Mathematics.*
H-183: Lieber, L. R., *Infinity.*
H-184: Lieber, L. R., *Einstein Theory of Relativity.*
H-185: Coleman, James A., *Relativitity for the Layman.*
H-198: Rademacher, H. and Otto Toeplitz, *The Enjoyment of Mathematics.*

GENERAL MATHEMATICS TOPICS

1. Systems of Numeration:
   B-40: 1–23.
   D-81: 13–29.
   D-83: 26–29.
   D-84: 1–157.
   F-132: 42, 46–52, 193–233, 273, 287–8, 291, 300, 334–6.
   F-133: 1–54, 151–4.
   F-135: 1–35.
   F-136: 20–34, 64, 166–8.
   F-147: 24–31.
   H-198: 66–73.

2. Natural Numbers and Zero:
   B-40: 24–31.
   D-82: 21–51.
   D-83: 38–9.
   D-84: 209–218.
   F-132: 75, 200–1.
   F-133: 1–71, 77–93, 111–150.
   F-135: Chap. A–B.
   F-136: 30–1.
   F-147: 3–7.
   H-183: 17–31.
   H-198: 9–13.

3. Fractional Numerals:
   D-82: 52–7, 79–83.
   D-84: 29–30, 48–50.
   F-135: Chap. A.

4. Decimal Numerals:
   D-82: 61–3, 66.
   D-84: 29–30, 48–50.
   F-135: Chap. A.

5. Intuitive Geometry:
   D-82: 299–303.
   D-84: 377–385, 420–445, 456–460, 479–492.
   F-132: 52–70, 115–192.
   F-133: 72–6.
   F-136: 10–1, 66–89, 208–211.
   F-147: 129–135.
   H-183: 250–262.
   H-198: 73–82.

6. Denominate Numbers:
   D-84: 51–78.

7. Business and Home Arithmetic:
   D-84: 224–245.
   F-132: 115, 394–462, 467.

NINTH GRADE ALGEBRA

1. Operations with Algebraic Expressions:
   D-82: 1–9.
   D-84: 164–185.
   F-132: 73–114, 287–346.
   F-135: Chap. 5.
   F-136: 1–26.
   H-184: 73.
   H-198: 34–42.

2. Positive and Negative Numbers:
   D-81: 29–36.
   D-84: 158–163.
   F-134: 168–171.
   F-135: Chap 5.
   H-183: 17–26, 77–99.
   H-198: 9–12, 66–73.

3. Linear Equations and Inequalities:
   D-84: 186–208, 564–574.

4. Variation:
   D-84: 246–263, 420–445.
   F-133: 158–182.

5. Linear Equations and Inequalities (2 variables):
   F-133: 158–182.
   H-184: 34–6, 150–165, 180–1.

6. Polynomial Expressions:
   H-183: 147–160.

7. Rational (fraction) Expressions:
   D-82: 52–7.
   D-84: 197–201.

8. Informal Deduction:
   E-115: Chap. 1, 3.
   F-135: Chap. 4, 5.
   F-136: 34–7.
   H-183: 100–8.
   H-198: 13–7, 22–6.

9. Quadratic Equations:
   D-84: 218–223.
   F-132: 318–9, 322–5.
   F-133: 158–182.
   F-135: Chap. 6.
   F-136: 104–7.
   H-183: 250–262.
   H-184: 8–11, 75–8, 150–165.

10. Numerical Trigonometry of Right Triangle:
    D-84: 377–385, 446–455
    F-132: 155–6, 234–281.
    H-183: 346–350.
    H-184: 60–6.

TENTH GRADE GEOMETRY

1. Informal Geometry:
   - D-81: 29–36, Chap. 4.
   - D-84: 420–445, 479–537.
   - F-132: 52–70, 115–192, 369, 388.
   - F-136: 10–1, 112–135.
   - H-198: 13–7, 73–82.

2. Deductive Reasoning:
   - D-82: 86–7.
   - E-115: Chap. 1, 3.
   - F-134: 129–137.
   - F-135: Chap. 4, 5, 317–331.
   - F-136: 42–5, 211–3.
   - H-183: 316–346.
   - H-184: 21.

3. Sequence of Theorems to the Theorem of Pythagoras:
   - F-132: 63, 66–7.
   - H-184: 109–115.
   - H-198: 27–34.

4. Coordinate Geometry:
   - B-40: 41–52.
   - D-82: 72–7, 488–495.
   - D-84: 365–376, 385–7, 406–419, 574–584.
   - E-115: Chap. 12.
   - F-132: 394–462.
   - F-134: 90–100.
   - F-135: 178–205.
   - F-136: 96–9.
   - H-183: 40–62.
   - H-184: 15–9, 60–9, 109–125, 141–7, 221.
   - H-198: 61–6, 139–146.

5. Additional Theorems and Problems:
   - H-183: 250–262, 351–5.
   - H-198: 103–110, 119–129, 160–177.

6. Solid Geometry:
   - D-82: 198–214.
   - D-84: 538–563, 585–608.
   - F-132: 347–393, 447.
   - F-147: 129–135.
   - H-184: 109–120.
   - H-198: 82–8, 177–187.

ELEVENTH GRADE ALGEBRA AND TRIGONOMETRY

1. Basic Concepts and Skills:
   - D-81: Chap. 3.
   - D-82: 101–3.
   - D-84: 706–727.
   - F-132: 287–346.
   - F-136: 49–56, 65–72.
   - H-183: 125–146, 182–194.
   - H-184: 70–2, 170–8.
   - H-198: 66–72, 187–192.

2. Linear Functions:
   - F-133: 158–182.
   - H-183: 161–182.
   - H-184: 141–147.

3. Radicals:
   - F-135: 99–108, 295–316.
   - F-147: 77–97.
   - H-198: 22–6, 111–9.

4. Quadratic Functions:
   - F-136: 104–9.
   - H-183: 40–62.
   - H-198: 17–22.

5. Quadratic Equations:
   - F-132: 318–9, 322–3.
   - F-133: 158–182.
   - F-135: 108–119, 179–184.
   - F-136: 89–104.
   - H-184: 8–11, 75–8, 150–165.

6. Systems of Equations:
   - H-184: 44–9, 60–9, 150–165.

7. Exponents and Logarithms:
   - D-82: 289–299.
   - D-84: 58–61, 65–7, 264–294.
   - F-132: 463–509.
   - H-184: 240–1, 253.

8. Series:
   - D-82: 12–5, 26–7, 315–6.
   - F-132: 48, 206–229, 325–336, 439, 467, 478–8, 492–3, 500.
   - F-135: 139–163.
   - F-136: 38–40.
   - F-147: 136–170.
   - H-183: 77–99, 147–160, 194–204, 209–227.
   - H-198: 95–103, 135–9.

9. Number Fields:
   - B-40: 31–8.
   - D-82: 21–6, 68–72, 88–104.
   - F-135: 164–205.
   - F-147: 57–64.
   - H-183: 17–26, 100–124.
   - H-198: 129–139, 147–160, 187–196.

10. Plane Vectors:
    - D-84: 609–640.
    - F-132: 504–6.
    - F-134: 171–4.
    - H-184: 127–140.

11. Coordinate Trigonometry and Vectors:
    - D-82: 277–282.
    - D-84: 609–640.
    - F-132: 234–286, 394–462.
    - F-147: 123–8.

H-183: 346–350.
H-184: 141–2, 230–3.

12. Trigonometric Formulas:
D-82: 92–100.
D-84: 392–406, 446–455, 460–8, 744–753.
F-132: 155–6, 234–281, 510.
F-136: 103–4.

TWELFTH GRADE ADVANCED MATHEMATICS

1. Elementary Functions:
B-40: 64–83.
D-82: 9–11, 18–20, 58–66, 77–9, 108–164, 272–283, 285–299, 307–310, 315–6, 322–361, 499, 500, 609–617.
D-84: 264–364, 372–6, 387–391, 392–406.
E-115: Chap. 25.
F-132: 487–493.
F-135: 57–76, 178–205.
F-136: 34–45, 66–99, 196–200, 223–243, 248–259, 261–3.
H-183: 27–39, 161–182, 204–8, 228–249, 263–345, 356–9.
H-184: 109–125.
H-198: 34–51, 61–6, 88–95, 103–110, 187–196.

2. Introductory Probability and Statistics:
B-40: 206–222.
D-82: 16–7, 361–3.
D-84: 329–353.
E-115: Chap. 22, 23, 24.
F-131: The Book
F-132: 595–653.

3. Introduction to Modern Algebra:
D-81: 29–36.
D-82: 31–51, 140–2, 288–9.
F-132: 78, 273.
F-135: 57–76, 164–205.
H-183: 137–146, 161–194.
H-198: 66–72.

4. Topology:
B-40: 52–63.
D-82: 235–269, 345, 496–9.
E-115: Chap. 26, 28.
F-136: 265–298.
H-198: 73–88.

5. Non-Euclidean Geometry:
D-81: Chap. 8.
D-82: 165–234, 495–6.
E-115: Chap. 10, 11.
F-134: 81–9, 137–167.
F-136: 135–150.
H-183: 32–9, 62–76.
H-198: 119–129, 177–187.

MATHEMATICAL RECREATIONS

General Interest and History:
B-40: The Book
D-83: 111–157.

D-84: The Book.
E-115: Chap. 19.
F-131: The Book.
F-132: 17–72, 115–7.
F-133: 94–110, 158–188.
F-134: The Book.
F-135: 36–56.
F-136: 156–165, 168–189.
F-147: The Book.
H-198: 73–82.

Section II: Reviews

B-38: Bell, Eric, T., *Men of Mathematics*. Simon and Schuster, New York, 1937. 593 pp.

"The lives of mathematicians presented here are addressed to the general reader and to others who may wish to see what sort of human being the men and women who created modern mathematics (were) . . . " This is not a history of mathematics, rather it is a series of stories about certain mathematicians whome we hold most responsible for the present-day scope and magnitude of mathematics. The basic science has come a long way in the more than 2500 years since Pythagoras.

This book is written for all who appreciate the fascination of mathematics and its applications, not just for the student of mathematics. High school mathematics students at all levels will find materials of interest at their level of understanding in this volume. This book is a must for the high school library.

B-39: Infeld, Leopold, *Albert Einstein*. Charles Scribner's Sons, New York, 1950. 134 pp.

This biography is a book to be read from cover to cover in the manner of a novel, and should not properly be classified as a reference book. It is one of a series of a dozen books entitled the Twentieth Century Library designed to give the interested layman a basic understanding of those thinkers in the last one hundred years who have most influenced the intellectual direction of our present-day thinking.

Author Leopold Infeld is himself a giant in his field who has worked side by side with Einstein for ten years. The level at which these men work is such that subjects such as mathematics, astronomy, physics and chemistry are so closely united that they become one field, namely, theoretical physics.

The book is written in prose—there are no formulae to frighten off the timid. Relationships are expressed in sentences and paragraphs, with the purpose of getting as many ideas across to the reader as possible without requiring college knowledge of the subjects discussed. Relativity, specific and general, and the quantum theory are expounded to those interested enough to keep reading. The thoughts expressed are certainly not simple ones, and none but the extraordinary junior high school student would be interested in trying to follow them. But the additional maturity of a few high school years should make it a proper choice for the senior high school library.

As well as explaining those main thoughts of modern physics the book serves as an excellent biography of Albert Einstein what kind of a man he was, and what his associates and contemporaries thought about him. Einstein's disregard for material things and worldly gain are delineated alongside his grander view of life and the world, and certainly worthy of high school reading.

B-40: Gamow, George, *One, Two, Three . . . Infinity*. The Viking Press, New York, 1954. 340 pp.

In the world of science, this book leaves few subjects untouched. The author, an internationally known scientist, is both expert in his field and a successful

chronicler to the public of the new scientific discoveries.

Starting out with "The still pure mathematics" of number theory, Gamow develops the idea of very large numbers and the concept of infinity. From there he goes into the unusual properties, the world of four dimensions, and Einsteinian relativity of space and time. Part three brings the reader into the microscopic world, chemistry, and heredity. Lastly, part four discusses the apparently expanding universe and a new explanation of the origin of our solar system.

The style of writing is certainly not heavy, with humorous anecdotes occasionally included such as the limerick;

> "There once was a girl named Miss Bright,
> Whose speed was much faster than light.
> She set out one day,
> In a relative way,
> And returned on the previous night."

The author does his own illustrating, of which there are over one hundred, and these diagrams and drawings aid greatly in putting the concepts across to the reader. Several photographs of the heavens and microscopy, including that of a molecule magnified 175 million times, aid the author's message.

This book can be easily read by an interested high school student, and most phases by the junior high school student. It should become a much-read addition to any school library. The book is indexed, but a few specific items and pages of interest to high school mathematics teachers are listed here:

Coordinates, rectangular and polar, p. 50
Map Coloring problem, p. 57
Theory of Numbers, pp. 34–47
Numbers, prime, complex, imaginary, pp. 35–44
Probability, p. 200
Tensors, p. 84
Geometrical Projection, p. 71
Polyhedrons, p. 55
Pythagorean Triangles, p. 40.

D-81: Logsdon, Mayme. *A Mathematician Explains.* University of Chicago Press, Chicago, 1947. 189 pp.

This is a good book to read when one has progressed far enough in mathematics to want an over-all view of the subject, or if a mature person wants to learn more about this important science which they may have neglected earlier. The author states that one of the purposes of this book is to look carefully into this subject which is commonly labeled "abstract" or "deductive" and show that these descriptive terms need not imply that behind them lie mystery and difficulty of comprehension, but rather beauty, elegance, and above all orderliness and simplicity.

This book should be encouraging to the student who feels somewhat lost in the maze of mathematical detail and help him fit into the whole field of mathematics the part he is currently studying. Plato said, " . . . Those who have a natural gift for calculating have, generally speaking, a talent for learning of all kinds, and even those who are slow are, by practice in it, made smarter."

The author explains mathematics in a simple understandable way with interesting historical background to the development of the various branches.

This has been a very popular book with two editions and ten reprintings.

D-82: Courant, Richard, and Herbert Robbins, *What is Mathematics?* New York: Oxford University Press, 1941. 521 pp.

The description in the booklet which outlines the books from the National Science Foundation Library states that: " . . . requires some high school math. . . . " This statement is true. Some high school mathematical background is needed to read this book, but courses in analysis would be essential to under-

standing the material. This book should be used most of the time as a teacher reference book and not as a supplementary text for the high school mathematics student.

D-83: Berkeley, Edmund C., and Lawrence Wainwright. *Computer: Their Operation and Applications.* Reinhold Publishing Corp., New York, 1956. 366 pp.

A revision of "Giant Brains," (an early work on the subject) which presents basic information about automatic computers. All of the elements of digital, analog, and miniature computers are explained. Of interest to mathematicians, physicists, and engineers and those who aspire to those professions. A glossary of terms and expressions is included.

D-84: Baskt, Aaron. *Mathematics: Its Magic and Mastery.* (2nd ed) D. Van Nostrand Co., Inc., New York, 1952. 790 pp.

The principles and practices of the basic mathematical processes are presented in this book in novel and entertaining ways. Even though the author has emphasized the fun in mathematics through his method of presentation and types of examples the book is not limited to tricks and puzzles. The main areas of the book are concerned with numbers and their properties, algebra and its numbers, and the mathematics of plane figures. The mathematics of daily life, business finance, and probability and statistics is also presented in this volume.

Mathematics: Its Magic and Mastery starts with numerals and numeration and moves through 37 chapters of applications to the different topics found in high school mathematics courses. Then there is an appendix devoted to major definitions and formulas in plane Geometry. Much of the material is applicable to General Mathematics courses. The first ten chapters are concerned with number facts, arithmetic calculation, measurement, and problems and puzzles. Chapters 18–24 deal with business mathematics and statistics and probability. Geometric figures are presented in Chapters 24–35. Chapters 12–17 are interesting aspects of Algebra.

This book would not be appropriate for the junior high school, but should be a valuable addition to the high school library since some parts of it could be related to practically every topic taught in a high school mathematics course.

E-115: Kline, Morris, *Mathematics in Western Culture.* Oxford University Press, New York, 1953. 484 pp.

This book does not lend itself to much direct application to the junior high or the high school mathematics curriculum.

It is an excellent presentation of the manner in which mathematics is woven into our life and thought. It shows how the work of the ancient mathematicians and that of mathematicians on up through the centuries have developed a systematic and logical science of number and have allied it with the sciences and arts in the broadest interpretation of these terms.

As one covers the pages of this book, it becomes apparent that pursuit of pure mathematics has often lead to interesting discoveries when an illustrative model from the universe was found to fit the pure abstract system. And too, starting from specifics, an attempt to systematize and generalize has often lead to the abstract. It seems then that pure mathematics and applied mathematics are both fruitful pursuits and serve to complement each other. This book makes the reader aware of the tremendous contribution that mathematics had made to culture in its far reaching effects.

It is an excellent book for any high school teacher to read of background material. It would serve well for the reading list for senior math club members in a high school.

F-131: Williams, J. D., *The Compleat Strategyst.* McGraw-Hill Book Co., Inc., New York, 1954. 234 pp.

An interesting book on the introduction of game theory. This book has applications to elementary statistical methods of tabular organization of material. The problems considered by the author are quite amusing. Most high school mathematics students should be able to read this book with understanding. The mathematics involves analysis, square tables, operations with signed numbers, and elementary calculations. Reading this book should help the student to see the importance of organizing information systematically. At the high school level this book is one primarily for recreational mathematics.

F-132: Hogben, Lancelot, *Mathematics for the Million*. W. W. Norton and Co., Inc., New York, 1944. 230 pp.

Here is a book, almost 700 pages long, that is filled with hundreds of excellent referable articles for interested high school students on any subject of high school mathematics that they will encounter from the seventh to the twelfth grades. It was written by a non-mathematician for the sheer fun of writing it, and that is the way it reads. Every high school mathematics teacher should be familiar with its contents, for here is a book that ties mathematics to history, astronomy, and the modern problems we face in our technological society. Albert Einstein himself had this to say about the book; "I find this book really meritorious because it makes alive the contents of the elements of mathematics."

One criticism, a book binding error, is a glaring one. An entire section of 32 pages is missing from the book (pp. 225–256), while the following 32 pages are included twice. Another copy I had read several years ago had this same defect. Surely the publisher is aware of this fact by now.

Mathematics for the Million contains thirteen chapters, five appendices, six pages of tables, four pages of answers to hundreds of exercises from chapters 3 to 11, and a very complete eighteen page index with cross references to over seventeen hundred entries. After an introductory chapter on mathematics as the mirror of civilization are, following in order, chapters on mathematics in prehistory, number language, geometry, arithmetic, trigonometry, algebra, spherical triangles, graphs, logarithms, the calculus, games, and statistics. The book is written with a vocabulary above the average junior high school student's level, but should present no particular difficulty for the senior high school student. It is an excellent addition to any school library.

F-133: Friend, J. Newton, *Numbers: Fun and Facts*. Charles Scribner's Sons, New York, 1954. 208 pp.

This is an excellent little book which is good reading for all students in the junior and senior high school. It tells you something about numbers, how they originated, and of the traditions, legends and superstitions that have collected around numbers. It would be a good book for the teacher to go to for information that would give the daily lesson that extra "something" so needed in many mathematics classes. In general, it is a book well worth reading and owning.

F-134: Lieber, Lillian R., *The Education of T. C. Mits*. W. W. Norton and Co., Inc. New York, 1944. 230 pp.

This 229 page book can hardly be applied to any specific mathematical subject, but rather to mathematics in general. It is a book which could be recommended for all high school students, because it is written in an elementary and entertaining fashion. Yet, it would seem that the contents would be rewarding to the students. Its touches of humor and diagrams appeal to both teen-agers and adults.

T. C. Mits is no more nor less than "The Common in the Street." He finds that a great deal can be learned from mathematics. This book explains classical mathematics, defending both the pure mathematicians as well as the applied ones. Such ideas as "Science is international," and "The more math we know, the easier life becomes," are presented in a pleasant way.

In addition to its presentation and explanation of classical mathematics, this book introduces modern mathematics in such a way that it is understandable.

It also shows a relationship of mathematics to art, science, philosophy and other fields.

F-135: Dantzig, Tobias, *Number: The Language of Science.* The Macmillan Company, New York, 1954. 340 pp.

This book would be appropriate many places in the high school mathematics program. The portions of the book on the concepts of infinity and the introduction to calculus is quite good. The material is on a level such that the best students can read and understand the book. This is a good book for the high school mathematics teacher.

F-136: Kasner, Edward, and James Newman, *Mathematics and the Imagination.* Simon and Schuster, New York, 1940. 380 pp.

This absorbing book has the following paragraph contained in its first chapter.

> . . . Watson Davis, the popular science reporter, has given us the name "mathescope." With the aid of the magnificent new microscopes and telescopes, man, midway between the stars and the atoms, has come a little closer to both. The mathescope is not a physical instrument; it is a purely intellectual instrument, the ever-increasing insight which mathematics gives into the fairyland which lies beyond intuition and beyond imagination. Mathematicians, unlike philosophers, say nothing about ultimate truth, but patiently, like the makers of the great microscopes and the great telescopes, they grind their lenses. In this book, we shall let you see through the newer and greater lenses which the mathematicians have ground. Be prepared for strange sights through the mathescope!

The book is a sort of mathescope in itself. It is written on a rather elementary level, so that high school students may read and enjoy it, yet it is quite informative, and most adults would find it interesting, also.

It contains a large portion which might be classified as modern mathematics and mathematical recreations. Reading this book should cause almost anyone to be more critical of the world of science around us. The book shows that the world of mathematics is truly one of fantasy generated from pure logical thought when mathematics is compared to the other sciences. The book is recommended for the layman as well as the high school mathematics student and teacher.

F-147: Meyer. *Fun with Mathematics.* World Publishing Co., New York, 1952. pp. 175.

This book is dedicated to all young people who like mathematics. It is full of gems that will delight and astound all those who are fascinated by the magic of numbers. The author has written many successful books for young people.

The early chapters introduce numbers used for expressing extremely large and small values. It explains some number systems other than ours along with interesting puzzles and mathematical oddities like the I X O H O X I. It is a magic square that is true upside down and backwards as well as in the original.

There are some ideas for mathematical projects or science fair projects such as building a slide rule, making a date indicator and sundial, and geometric models.

The language used is clear and this book should be easy to read for the average high school student.

H-183: Lieber, Lillian. *Infinity.* Rinehart and Company, Inc., New York, 1953. 395 pp.

Lillian Lieber's style and form of writing are so different and intriguing that the reader becomes fascinated with any material which is presented in such an unusual manner. Through this medium, she has made infinity a most fascinating subject and at the same time presented much imaginative, creative, and basic mathematics.

Infinity in the physical world is discussed followed by a most complete presentation of infinity in mathematics. This includes potential infinity, asymptotes in hyperbolic, elliptic and parabolic geometries, Cantor's creation of a theory of sets from a system of actual infinities, rational numbers infinite sets in which the whole set can be equivalent to a part of itself, laws of finite number, well ordered pairs of numbers, and higher dimensions with examples of the binomial theorem, square, and cube.

The last part of the book is concerned with limits in the Calculus which is too advanced for use in the high school.

The greater part of this book is appropriate for use as supplementary material in advanced high school mathematics classes, and it should be a part of the high school mathematics library. It should also help the young mathematics student see that mathematics is an elaborate structure created by the human mind from seemingly insignificant beginnings, like a few postulates.

H-184: Lieber, Lillian R., *Einstein Theory of Relativity*. Rinehart and Co., New York, 1945. 324 pp.

The intention of this book is to explain the Einstein Theory of Relativity to readers with some knowledge of mathematics to bridge the gap between those explanations containing no mathematics and those so steeped in the subject that only a select few can follow. The cartoons and drawings by the author's husband enliven the text and give a reassuring feeling to the reader that the mathematics encountered, and there is plenty of it, is not too stratospheric in nature to be understood. The author feels that mathematical explanations of some phases make clear what would otherwise become "mystical" in the ordinary language of words.

Concerning the mathematics considered necessary in reading this book, a good and complete high school college-prep math course would be considered most useful, although not entirely necessary provided many statements are accepted as being so when they are made. Euclidean, non-Euclidean, and solid geometries are discussed, as is logic, trigonometry, calculus, vectors, tensors, and even tensor calculus. In addition, determinants and the elements of matrix theory are encountered. In high school it would be the best of the physics and math students that would wade into this work, but those that did would find such tie-ins to past experience and basic math that it would often serve as a better introduction to many phases of collegiate math than many standard textbooks would be.

Although it is doubtful that any high school student would be able to understand everything presented in the book, it would serve its purpose in giving an insight to the prospective college student in the sciences into the type of ideas he will be working with later in his educational career. For this reason, if no other, it makes its contribution to the high school library.

H-185: Coleman, James A. *Relativity for the Layman*. The William Frederick Press, New York, 1954. 131 pp.

This book about relativity was written primarily for those who have had little or no training in mathematics, physics or astronomy. It presents the scientific history which preceded Einstein's theory of relativity, a complete account of the theory itself, and a description of the various proofs of the theory. All mathematical details concerned with the proofs of the postulates have been omitted, so that there is actually no mathematics at all in the book. The author purposely left out the mathematical details so that the reader who was not trained in mathematics would have no difficulty in grasping the main concepts of the book.

Coleman has given a most interesting and understandable account of Einstein's conception of the universe, and the book may be read as easily as one would read fiction.

High school students interested in science will be much more interested in this book than the mathematics student. It would be of no particular importance in

a high school mathematics library other as background information on the importance of mathematics in scientific development.

H-198: Rademacher, Hans and Otto Toeplitz. *The Enjoyment of Mathematics, Selections from Mathematics for the Amateur*. Princeton University Press, Princeton, New Jersey, 1957. 240 pp.

This book is designed for the person who is interested in mathematics and who has considerable knowledge of the structure of this subject. Much of the material is concerned with proofs of basic mathematical concepts. For example, Chapter 1 presents Euclid's proof of the sequence of primes; Chapter 7, Cantor's theory of sets; Chapter 15, an investigation into the theorems of the arithmetic and geometric means; and Chapter 20, Euler's proof that primes are infinite.

This book would be of little interest to the average high school student; however, the advanced high school mathematics student would find much of the material presented interesting and enjoyable. The book is not difficult to read if one has sufficient mathematics to follow the development of the various theories and problems presented.

Probably the most important use of such a book at the high school level would be as a teacher reference for supplementary material in advanced mathematics classes.

MAN NEEDS BOTH NIGHT AND DAY IN OUTER SPACE

Man may have to take night and day artificially with him into space to keep him and his "living clocks" ticking, Dr. Colin S. Pittendrigh, professor of biology at Princeton University, said.

"Living clocks" are the innate physiological rhythms that govern the biological functioning of all living organisms except bacteria. The rhythms depend to a great degree upon the light cycle alternating from day to night, the biologist explained.

"In man, for instance, there is a regular waxing and waning of sugar content in the blood, of body temperature, of endocrine gland activity," during this alternation, Dr. Pittendrigh said. His research has shown that these rhythms are matched to the period of the earth's rotation, which produces cycles of light and dark.

Without the cycle, these "living clocks" either might run too fast, too slow or even break down altogether, causing "stress, damage, even death to the organism.

"This means, among other things, that an aperiodic space capsule could very likely damage human passengers," Dr. Pittendrigh warned. The solution, however, is simple, he said. "It's simply a matter of lighting."

SCIENCE TEACHERS GROUP LAUNCHES MAJOR STUDY OF SCHOOL SCIENCE FACILITIES

If laboratory experience is the best way for a child to learn science—and most teachers believe it is—the lack of school laboratories and other physical facilities can put a real crimp in the current lively efforts on several fronts to improve the science curriculum.

So says the National Science Teachers Association (NSTA) in launching a major national Science Facilities Study. Its purpose: to determine the physical setting and tools which must undergird a topnotch school science program all the way from kindergarten through junior college.

Principal investigator will be Fred R. Schlessinger, associate professor of education, The Ohio State University at Columbus. He will be assisted by an eight-man steering committee. The study is supported by a grant from the Laboratory Equipment Section of the Scientific Apparatus Makers Association, which will look to NSTA for guidance in planning requirements of school science programs in the next decade.

The Chemical Education Materials Study Approach to Introductory Chemistry*

R. L. Silber

American Chemical Society, Washington, D. C.

History and Organization

In 1958, an Ad Hoc Committee was appointed by the American Chemical Society to study the possibility of revising the high school chemistry course. Dr. Alfred Garrett, Chairman of the Chemistry Department at Ohio State University, was named Chairman of the Committee. The Committee consisted of college professors of chemistry and a high school chemistry teacher. The Ad Hoc Committee, after deliberation, recommended that a revision be made of the high school chemistry course and suggested, in general, what the course should contain. Dr. Glenn T. Seaborg, Chancellor of the University of California, Berkeley, California, was asked to be Chairman of the revision program. Doctor Seaborg, as Chairman of the program, named Dr. J. A. Campbell of Harvey Mudd College, Director of the project. A Steering Committee was appointed which consisted of college professors, high school teachers and other specialists. The members of the Steering Committee other than Doctor Seaborg and Doctor Campbell were as follows:

Dr. Bryce Crawford, University of Minnesota, Minneapolis, Minnesota
Mr. Warren Everote, Vice President, Research and Development, Encyclopaedia Britannica Films, Chicago, Illinois
Mr. Cleveland Lane, Sutherland Educational Films, Los Angeles, California
Dr. Donald H. McLaughlin, University of California, San Francisco, California
Dr. Carl G. Nieman, California Institute of Technology, Pasadena, California
Dr. J. Cecil Parker, University of California, Berkeley, California
Dr. Charles Price, University of Pennsylvania, Philadephia, Pennsylvania
Dr. Kenneth S. Pitzer, University of California, Berkeley, California
Mr. Robert Rice, Berkeley High School, Berkeley, California
Mr. Robert L. Silber, American Chemical Society, Washington, D. C. (formerly Central High School, Evansville, Indiana)
Mr. Grant Vest, State Department of Education, Salt Lake City, Utah
Dr. Roy L. Whistler, Department of Biochemistry, Purdue University, Lafayette, Indiana
Dr. Rolland B. Gladieux, Kenmore Public Schools, Kenmore, New York

The first meeting of the Steering Committee was held in January 1960 at the University of California in Berkeley. At this meeting, the Steering Committee projected the following:

1. A decision to write a text in the summer of 1960 rather than waiting another year was made. The writing project would be directed by Dr. George Pimentel, University of California, Berkeley.

* A paper presented at the Annual Meeting, Central Association of Science and Mathematics Teachers, Detroit, Michigan, November 24-26, 1960.

2. The course should be new, emphasizing principles, theories and understandings of chemistry. Descriptive chemistry would be woven into the course as examples to illustrate the principles. Such subjects as the manufacture of steel, sulfuric acid, etc. would be eliminated as individual studies. The course should be linked directly with the laboratory, thus demonstrating chemistry as an experimental science.
3. Laboratory experiments should be developed. These should be of a new open end type of experiment which will be integrated with the text. They should illustrate the principles and not be of the "cookbook" type. Dr. Lloyd Malm, University of Utah, Salt Lake City, Utah, would direct the laboratory manual project. The recommendation of establishing two-period laboratory sessions was unanimous, if it could be inaugurated in the high schools.
4. Films should be made which would explain, illustrate, and demonstrate, principles and subjects which cannot be easily presented in the classroom. Mr. Dave Ridgway, formerly of Encyclopaedia Britannica Films, Inc. and Director of the John Baxter film series, would be Director of the film project.
5. Monographs should be written by specialists in the various areas of chemistry in order to supplement the textual material and to further the interest and depth of the gifted student. These should generally be approximately 100 pages in length and will be written in conjunction with a professional writer in order to obtain clearness of presentation.
6. Other areas of investigation were suggested. Among these are teaching machines, film strips, models, kits, etc.

Progress and Present Status

A writing conference was held in June and July, 1960 at Harvey Mudd College, Claremont, California. Nine college professors and nine high school teachers wrote the textual and laboratory materials. The first draft of a complete text was prepared and the first volume was rewritten and edited. One semester's laboratory experiments were written and tested. Members of the writing session group were:

Robert F. Campbell, Miramonte High School, Orinda, California
Joseph E. Davis, Jr., East High School, Salt Lake City, Utah
Saul L. Geffner, Forest Hills High School, Forest Hills, New York
Theodore A. Geissman, University of California, Los Angeles, California
Melvin Greenstedt, Fairfax High School, Los Angeles, California
Edward L. Haenisch, Wabash College, Crawfordville, Indiana
C. Robert Hurley, Sacramento State College, Sacramento, California
Keith McNab, Sir Francis Drake High School, San Anselmo, California
Bruce H. Mahan, University of California, Berkeley, California
Lloyd E. Malm, University of Utah, Salt Lake City, Utah
Margaret Nicholson, Acalanes Union High School, Lafayette, California
Clyde E. Parrish, Cubberley Senior School, Palo Alto, California
Robert W. Parry, University of Michigan, Ann Arbor, Michigan
George C. Pimentel, University of California, Berkeley, California
Michell J. Sienko, Cornell University, Ithaca, New York
Robert L. Silber, American Chemical Society, Washington, D. C. (formerly Central High School, Evansville, Indiana)
Luke E. Steiner, Oberlin College, Oberlin, Ohio
Robert E. Tellefsen, Napa High School, Napa, California

The first nine chapters of the text was multilithed and made available to a group of 23 selected high school teachers from the Los

Angeles and San Francisco areas, with one additional teacher from the New York City area. These teachers studied the material for four weeks on the campus of Harvey Mudd College in August, 1960. They performed all of the experiments involved in the first half of the text. Chapter titles from Volume I of the trial edition of "Chemistry—An Experimental Science" will give you an insight into the nature of this developing course.

Chapter Headings for Volume I

I. Chemistry: An Experimental Science
II. Introduction to Atomic Theory
III. Atoms Combined in Substances
IV. Chemical Reactions and Phase Changes
V. The Gas Phase: Kinetic Theory
VI. Substances and Solutions
VII. Chemistry and the Periodic Table
VIII. Geochemistry: The Earth as a Source of Material
IX. A General View of Chemical Reactions

At the present time, the course is being taught in 23 high schools in California and one in New York City. $400.00 was made available to each teacher from the CHEM Study to purchase equipment necessary to conduct the experiments in the course at their local schools. Weekly meetings are held with staff members from the CHEM Study and the teachers of the course, in order to discuss problems, changes, etc. The New York teacher corresponds by mail in the discussion of his problems. The second volume has recently been made available to the participating teachers. The third volume of the book will be available in January 1961.

Several films are being scheduled and should be in production by the end of November. Two films are being sponsored and filmed in cooperation with the Manufacturing Chemists' Association. Tests are also being constructed and will be evaluated by the Educational Testing Service.

Future Plans

In the summer of 1961, two Summer Science Institutes will be conducted for chemistry teachers. One will be at Harvey Mudd College and the other at Cornell University. Approximately fifty teachers of high school chemistry will attend each Institute where they will receive instructions concerning the CHEM Study course. These teachers will then teach the course in their respective high schools in the 1961–62 school year. Thus, more than 6,000 students will be exposed to the course in the next school year (1961–62). A second

revision of the text and laboratory manual will be made during the summer of 1961. Some monographs and films should be available for the 1961–62 school year. Nine geographic centers—Claremont, Berkeley, Philadelphia, New York City, Indianapolis, Northern Florida, Seattle, Minneapolis, and Chicago—will be operating during the school year 1961–62 in order to conduct weekly meetings with the teachers. In the summer of 1962, a final revision of the textual materials and laboratory manual will be made and the materials then published on a large scale. Other future activities are not definite but the possibilities of expansion in the area of chemistry and chemical education are entirely feasible.

General Comments

The course is designed for the average high school chemistry student and not directed at a particular group. The program Director, Dr. J. A. Campbell writes:

> "The text assumes that students believe in atoms and molecules, but that they do not understand the reasons behind these beliefs. Introductory chapters present an overview of chemistry in terms of the atomic-molecular nature of substances and develop concepts of behavior in terms of atomic theory and energy changes. The periodic table is introduced as a means of ordering chemical information. The second section deals with some of the most basic concepts of chemistry, again from the experimental point of view. Chapters on energy, rates, equilibrium, acid-base, and oxidation-reduction are tied together in terms of the mole concept, the kinetic theory, and the atomic-molecular concept of behavior in matter. Material designed for the second semester begins with a discussion of atomic and molecular structure and of structural relationships in the various states of matter, together with their influence on chemical reactivity. The chemistry of carbon and of typical elements in the periodic table is studied, particularly as to the trends in properties as one moves through the rows and columns of the table. Emphasis in these sections is on the experimental approach with the intent of utilizing the materials and ideas presented earlier to tie chemical knowledge together."

The course is designed so that built-in or automatic devices, such as the monograph program, will help take care of the gifted student. The text material also is written in such a way that the student cannot always obtain the answer from the textbook and must rely on his ability to seek the answers from other sources. This is entirely different from most textbooks presently on the market. Also, the course is closely integrated with the laboratory and actually carries out the

theme of being an experimental science. The course was developed so that a broad understanding of the principles of chemistry is obtained with sufficient depth to enable the student to be able to cope with new problems presented in college or later life. The project is supported by a grant from the National Science Foundation and is similar to other projects being conducted in the fields of biology, physics and mathematics.

If further information is desired concerning the project, write to:

CHEM Study
Dr. J. Arthur Campbell
Harvey Mudd College
Claremont, California

BLACKENED SPIDER WEB INCREASES OPTICAL ACCURACY

Optical instruments can now be used with greater accuracy, thanks to a spider web blackening process.

Spider webs, which serve as fine cross hairs in gun sights and optical devices requiring sharp focus, usually are used in their natural, translucent state because they cannot be painted, lacquered or dyed without increasing their size. The bright lights used for microscopic focusing pass through the colorless web and produce a fuzzy-edged outline that makes it impossible to determine the exact point of focus.

The new opaque-blackening process eliminates both the fuzziness and size problems by taking advantage of the spider web's porous quality.

The two-stage technique, consists of placing the web in an atmosphere of vaporized reducing agent, such as hydrazine, and then in a chamber containing vaporized metal oxide, preferably ruthenium tetroxide or osmium tetroxide. In five hours or less, the web is saturated with enough of these agents so that it is black and opaque, but has not increased in size.

SCIENTISTS READ EARLY HISTORY FROM LAKE BOTTOM SEDIMENT

Sediment from the bottom of a small lake north of Rome has provided scientists with a history of events dating back as much as 25,000 years ago.

Prof. G. Evelyn Hutchinson, Yale University zoologist, reported to the American Philosophical Society meeting results of an intensive pollen analysis she made with Dr. Ursula Cowgill of two three-meter cores taken from the bottom of Lake Monterosi.

The deepest layer of the sediment was laid down, Prof. Hutchinson reported, in the interstadial between the second and third episodes of the Wurm glaciation, an event dated by geologists as in the neighborhood of 25,000 years ago. At that time, the pollen analysis indicated, the surrounding country was practically treeless and tundralike.

A species of Artemisia, a genus that includes the sagebrush and shrubs of the aster family, was the principal pollen producer at that time.

After about a third of the sediment had been deposited, a pioneer hazel community developed, followed by fir and then mixed oak forest.

In the top quarter of the core, the scientists found plantago pollen, giving evidence of agriculture in a region archaeologists believed to have been unhabited at that time.

Algebra in the U.S.S.R.: A Comparative Study on the Junior High Level

G. H. Miller

State Teachers College of Towson, Baltimore, Md.

With the launching of the first satellite on October 4, 1957, a new interest in Russian education was born. For, on this day, the belief in the inferiority of the Russian educational system was shown to have an extremely weak foundation. It was obvious that this great scientific achievement could not have been made without a large number of highly competent scientists and well-trained technicians. If there was any doubt about the first launching being a chance occurrence, Sputnik II which contained one dog and Sputnik III which could be seen with the naked eye, soon removed these doubts (5). Exactly two years after their first satellite, the firing of Lunik III showed a marked superiority in orbital computation and scientific apparatus synchronization. This performance demonstrated even greater precision than any of their previous efforts.

During the first few days after Sputnik I was thrust into orbit, there was much discussion of this feat. Later the discussion shifted into a series of attacks on our educational system in the radio and the press. Reports from many sources indicated that the Russian students were more advanced in mathematics than the American students. Since accurate information was not available at that time, the reporting sources could not be checked. However, with the introduction of Russian textbooks and educational periodicals on the American market, and with the information from educators who visited Russia, a more thorough analysis has been made.

Since the degree of scientific achievement is a by-product of a sound educational program, many questions concerning the educational program of the Russians were being asked. Are the Russian students actually ahead of American students in mathematics? What type of program in mathematics do they have? What specific mathematical topics do they teach? How do their textbooks compare to ours?

Because these questions cover such a large area, the present article will consider only the algebra program of the sixth and seventh grade which approximates the seventh and eighth grades of our junior high school. This is an appropriate comparison since all students in both countries are required by law to attend school during these years. The secondary program of the eighth, ninth and tenth grades of the Soviet ten-year school were not considered since the content of these courses may undergo some extensive changes in the next few years (8).

The data in this study have been obtained from original transla-

tions of Russian algebra texts and other supplementary material by the author and from other translations on information about Russian education.

Comparisons of the Algebra Programs

In the U.S.S.R., students start the official ten-year school at the age of seven and finish at the age of seventeen. The number of hours of mathematics given during the week is a total of six.

The problems of what topics to teach and the time allotments for algebra for all classes is controlled by the government. A pamphlet "The Program for Secondary Schools" (6) is printed each year and the specific topics, their time allotments, and the amount of homework are specified. Mastery of this material is essential, since Russian students must pass tests on these topics in order to go on to the university.

According to "The Program for the Secondary Schools" (for 1959–1960), all schools are required to provide six hours of mathematics a week. The recommendations for the sixth grade are as follows: Arithmetic—four hours a week for the 1st semester; Algebra—four hours a week during the second semester; and Geometry—two hours a week for both semesters. During the seventh grade, the following topics are specified: Algebra—four hours a week during the year; and Geometry—two hours a week during the year. The total amount of class time spent on algebra during the sixth and seventh grades, the last two years of the Seven Year School, is a minimum of 198 hours. Homework is to be assigned in amounts which equal approximately fifty percent of the class time.

In the schools of the United States, the students start at the age of six which is one year earlier than the Russian students. The general practice is to devote five class periods of algebra a week in the junior high school on the ninth grade level. Although there are a few schools which instruct algebra in the eighth grade (7), practically all schools place the topic of algebra in the ninth grade. In a large number of schools this topic is given only to those students who are considered to have a sufficiently high I.Q. to master this abstract material. There is no definite sequence of topics recommended for algebra in our schools and therefore the instructor is free to choose any or all of the topics from the required textbook. This situation leads to a diversity in the intruction of topics in algebra at this level.

It should be noted that all students take algebra in the U.S.S.R. as part of their compulsory education in contrast to students of various systems of the U.S.A., which provide anywhere from 15% to 100% of their students with training in algebra* (2). A great emphasis is

* Based on data from information gathered by the author and by the U. S. Office of Education.

placed on mathematics in the Soviet curriculum and is considered by the educational authorities in high government positions as being a valuable aid for the intellectual development of their students. Thus the value of mental discipline, i.e., the development of mental ability by means of mathematics courses, is held in high esteem in the U.S.S.R. In contrast, this philosophical viewpoint has fallen into disrepute in this country at the present time.

There is a noticeable difference between the Russian and American systems. In Russia all students go on to high schools and universities with a similar background. In the U.S.A. where no specified topics are required for the first-year algebra students, the American students will arrive with varied backgrounds in algebra although they have taken the same courses. Also the Russian students have one more day a week in which to work on mathematics. Another difference is that the Russian students start algebra three semesters earlier than our ninth-grade students start their work.

One feature of both systems is that educators are proposing changes in the present curriculum. The Russians are considering a compulsory eight-year school to replace the present goal of ten years of compulsory education for all. The eight-year school would be followed by three years of high school with combined work experience. After this training the students would have to pass examinations before going on to the university. However, these proposals are still subject to debate within the country. In the U.S.A., the proponents of "modern mathematics" are suggesting many changes in the curriculum which will make the mathematics more rigorous. And, as in Russia, these ideas are now widely discussed.

Comparison of Textbooks

The text "Algebra" by A. N. Barsukov is used throughout the 15 republics of the U.S.S.R. It contains the explanations of the topics of algebra. Translations of this text into the languages of the republics and of other ethnic groups within the republics are made available by the government printing department. In addition to the 160 page basic text by Barsukov, there is a text of 240 pages with problems and answers—"A Collection of Problems for Algebra," (Part I) by P. A. Larechev. This text of problems follows very closely the development of the topics indicated in the explanations in Barsukov's text. Although these are the official texts, the government does permit the use of other texts under certain conditions (3).

The chapter headings and summary of chapter contents for 'Algebra' (Part I) by Barsukov are as follows:

Chapter I. Algebraic Expressions. Equations

Basic definitions and properties of algebra such as the application of

letters as used in the commutative and associative laws of addition, the use of the formula, inequalities, permissible values of letters, coefficient, simple exponents and order of operations. A short introduction to equations.

Chapter II. Rational Numbers

Positive and negative numbers. The number line. Comparison of rational numbers. Concept of absolute value. Addition, subtraction, multiplication, and division of rational numbers which included the use of the commutative, associative and distributive laws and other additional properties of these operations. Straight line and broken line graphs. Solution of equations. A short history of mathematics.

Chapter III. Operations with Algebraic Expressions

Definitions of monomial, polynomial, identity and identity transformation. The operations of addition, subtraction, multiplication, and division with monomials and polynomials. Basic laws of exponents (multiplication, division, involution). Special products and their inverse operations.

Chapter IV. Factoring of Polynomials

Common monomial factor. Factoring by grouping. Factoring with the use of the special products. Factoring involving more than one method.

Chapter V. Algebraic Fractions

Concept of algebraic fraction. Basic characteristics. Equivalent fractions with different signs in the numerator and denominator. Reduction of fractions. Changing fractions to the least common denominator. Addition, subtraction, multiplication, and division of fractions.

Chapter VI. Equations of the First Degree in One Unknown

Definitions of equation, root of equation and proof of equation by checking. Concept of dependent equations. Basic properties of addition of equals and multiplication of equals. Equations of the first degree in one unknown, including the prescribed procedure for solution. Equations with unknowns in the denominator. Concept of inequality and its general properties. Inequalities of the first degree in one unknown. A short history of algebra.

Chapter VII. Equations in Two Unknowns

Introduction to coordinate geometry. Definition of equation in two

unknowns. Graphing of these equations. Slope of a line. Inverse proportional dependence ($XY = K$). Linear dependence.

Chapter VIII. Systems of Equations in the First Degree

Systems of two equations in two unknowns. Equivalent systems. Methods of solving systems of equations in two and three unknowns.

It should be noted that all of these topics are indicated for study in the "The Program for the Secondary Schools" and in fact this text was written for this purpose (8).

An analysis of twelve of the most commonly used American textbooks in algebra (book I) showed that these texts had many topics in common. Practically all of these texts contained explanations and problems on the following topics (indicated by chapter headings or sub-topics):

1. Formulas
2. Algebraic symbols
3. Equations
4. Signed numbers
5. Polynomials
6. Equations of the first degree
7. Linear equations in one and two unknowns
8. Graphs of equations in one and two unknowns
9. Pairs of linear equations
10. Special products and factoring
11. Fractional equations
12. Roots and radicals
13. Quadratic equations
14. Ratio, proportion and variation
15. Numerical trigonometry.

Other topics included in some of the first year texts were:

1. Logarithms
2. Slide rule
3. Proofs

Although the topics covered in most texts were similar, there were some noticeable differences in the development of these topics. These varied from the traditional presentation to the use of "modern" abstract proofs in the working of algebraic problems.

In comparing the Russian texts with the American texts, some salient features appeared. Most conspicuous was the fact that the texts of both nations contained approximately the same content of topics in traditional algebra. Although the Russian texts had no work on radicals in their basic texts for Part I (this topic is considered thoroughly in Part II), as observed in the twelve American algebra texts, they did consider one topic which was not indicated in any of the American texts—inequalities. Another difference is that the Russians use one text for explanations and development of the topics and another text for problems.

A major portion of the definitions and principles of algebra are introduced in the first chapter of the Barsukov text. The processes and explanations of operations are based on these principles and reference is made to the basic laws and definitions. In addition, there is an integration of the principles of arithmetic and algebra. Problems in algebra are worked and reference is made to the corresponding principle in the elementary arithmetic text. For instance: reference is made to the use of the commutative law for addition which was introduced in arithmetic and then the explanation continues to show how this law is used with letters (pages 1–3). This technique of reference to previous texts can be more readily applied in the Soviet Union since there is one set of official textbooks for each grade level.

The American texts do not appear to have as theoretical an approach in the development of the topics of algebra. In the Russian texts such theoretical concepts as permissible values of an unknown, impossibility of division by zero, the identity transformation, the additive inverse, the unity element and algebraic proofs are considered. However these concepts were usually explained in a very terse and sometimes incomplete manner.

The vocabulary and grammatical construction of the Russian texts was more complex. The American texts of the first year of algebra emphasize the use of simple language. Despite these theoretical considerations in the Russian texts, there seems to be a great emphasis placed upon prescribed methods for the solution of problems. Many examples were worked out in a step by step procedure.

There were some notable differences in the types of problems. The first was in the use of problems that include all four basic operations involving many different types of algebraic computations. American texts seem to utilize only one or two operations in computations of problems. The second point is that approximately fifty per cent of the text by Larechev was devoted to these written problems which shows the great emphasis that is placed on the value of statement problems. The emphasis in American texts is more toward the computational aspects as against the working of statement problems. The third difference shows an emphasis upon tedious mathematical computation as is indicated by the many complex problems in the text by Larechev. Thus, despite some stress in the Russian texts on the theory, there seems to be a greater emphasis upon working problems to obtain computational skills, just as we do in the U.S.A. These techniques are advocated by the proponents of traditional algebra. The following are some examples of these types of problems.

Problem 801-1 (page 128)

$$\frac{a^2}{a^2-b^2}-\frac{a^2b}{a^3+b^3}\cdot\left(\frac{a}{ab+b^2}+\frac{b}{a^2+ab}\right):\frac{b}{a-b}=\frac{a}{a+b}.$$

Problem 1147 (page 184)

$$\frac{5}{2x-3y}+\frac{2}{3y-z}-\frac{2}{5x-z}=\frac{1}{20}$$

$$\frac{10}{2x+y}+\frac{5}{3y+z}-\frac{3}{5x-z}=\frac{2}{5}$$

$$\frac{20}{2x+y}+\frac{20}{3y-z}-\frac{20}{5x-z}=-5$$

Problem 1249 (Page 207)

A shop received an order; $\frac{2}{3}$ of the order was completed by the foreman and the remaining part was finished afterwards by his assistant in such a way that the complete order was finished in 6 hours and 40 minutes after the beginning of the work. If the foreman would complete $\frac{1}{3}$ of the order and the remaining part would be finished by the assistant, then the whole order would be finished in $7\frac{1}{2}$ hours. In how many hours would it be possible to complete the order if each of them worked by himself?

Space appears to be at a premium in the Russian texts for the pages are crowded with problems. The Russian texts are printed on inferior quality paper and lack the excellent use of color which is used in the American texts. The Barsukov text also contained fewer diagrams and pictures. The reason for the difference in visual appearance is that less money seems to be allocated for the textbooks of student in the U.S.S.R.

Concluding Remarks

This analysis showed that the Russian and American texts contained approximately the same content of traditional topics in algebra and thus equivalent material was taught to the students of both countries. The great difference occurs in the grade placement when these topics are introduced. With the exception of a few schools in the U.S.A., the Russian students start three semesters earlier. In some schools of the U.S.A., algebra is provided only to the brighter students on the assumption that those of average and low intelligence cannot absorb these complex topics, while in others it may be taught to all students. We may conclude from this evidence that we may be too restrictive in our requirements, for the Russians not only teach algebra to all their students but also begin at an earlier age.

Perhaps one reason for the delay in the instruction of algebra in the United States is the tradition of giving our students a review of arithmetic and consumer mathematics on the junior high level. This presentation has been part of the program to prepare students for practical applications in their daily lives. Since the review of previous material in arithmetic is given throughout the Russian texts, no semester or year is designated for review. Nor is there any effort made to teach the students how to manage their money, or how to write checks, or how to figure out insurance. Since these are obvious trademarks of capitalism, it can readily be seen why such topics as consumer mathematics would not be included. Instead, the Russian students are given a scientifically-practical course—algebra.

In the construction of their texts, the Russians have economized on paper and materials. Only a minimum amount of space is used to cover the various topics and may explain the cryptic developments of the topics as well as the definitions in some of the chapters. This tendency to economize is quite different from the American junior high school texts which are models of perfection, utilizing the best in design, in diagrams, and in application of color. The economy of the Russian text by Barsukov does have the advantage that only the topics which are required for mastery are in the contents of the text. However the text by Larechev has a surplus of problems so that the students have more than enough work to do. In contrast, the American texts have a surplus of material in topics which is in some ways responsible for the difference in algebraic backgrounds of students since these texts contain more than a year's work for most students. Despite the poor quality of the Russian texts from an external appearance, the contents compare somewhat favorably to American texts. And, after all, the external appearance is a minor consideration, for the contents of the algebra taught are of greatest importance.

It has been pointed out that the Russian texts made use of a greater amount of theory in the presentation of topics in algebra. However, an analysis of the type of problems which the students are required to work shows that a great emphasis is placed upon routine computation. Problems which would never appear in any American texts because of the drugery of the work involved are used most generously in the workbook by Larechev. Evidently their aim is to have students compute accurately even though the problems may be complex.

The topic of inequalities arises very early in the work on algebra and indicates the importance of this topic in Russian mathematics education. The contents are closely related to the usual course work given in the traditional United States college algebra program in inequalities. Since this topic is very useful in analysis for higher mathematics, it is a valuable part of their program. This is one of the topics

which is considered important to those advocates of "modern mathematics," and is thus one of the common subjects that both groups of educators consider.

Perhaps the major advantage of the present Russian education should now be brought into focus. By having all students take algebra as part of their compulsory education, these students are more qualified to handle the requirements of science and technology. In view of the fact that our world is becoming more complex through technological advances, the great need for mathematics becomes essential. Algebra can serve as a valuable preparation for scientists and technicians to produce greater scientific achievements in atomic energy, computing machines, and satellites.

Thus the Soviet society may have a definite advantage at the present time because of their earlier educational emphasis on algebra to all of their students.

Recommendations

The analysis of this study points to the following recommendations:

1. Instruction in algebra should be considered at an earlier age and offered to a greater percentage of the students. However, a sound program based on research must be provided to produce maximum results.

2. More data should be obtained concerning the instruction of algebra in the U.S.S.R. Instructors know that all students cannot learn arithmetic, let alone algebra, despite the claims of the Russians. We should find out what they do with their students of low ability.

3. The value of the instruction of consumer mathematics and review of arithmetic in the junior high level should be opened for discussion so that it may be evaluated in light of present-day requirements.

For, with the better background in mathematics that algebra can provide, our nation can better meet the continuing challenge of Russian scientific advances.

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Predicting Terminal Digits of Squares and Cubes

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A glance at any table of squares and cubes (excepting squares and cubes of ten and multiples of ten) will confirm that their terminal digits follow the series 1, 4, 9, 6, 5, 6, 9, 4, 1 and 1, 8, 7, 4, 5, 6, 3, 2, 9 respectively. It is amusing to speculate whether other than terminal digits can be predicted by discovering order in their series.

Let t = the tens digit. Then multiplication and addition will produce the next to last digit of any square or cube. It is only necessary to apply the correct formula, as given below, to the root of the square or cube being examined.

Root	Square Formula	Cube Formula
11, 21, 31, · · ·	$2t$	$3t$
12, 22, 32, · · ·	$4t$	$2t$
13, 23, 33, · · ·	$6t$	$7t+2$
14, 24, 34, · · ·	$8t+1$	$8t+6$
15, 25, 35, · · ·	$0t+2$; or 2	$5t+2$
16, 26, 36, · · ·	$2t+3$	$8t+1$
17, 27, 37, · · ·	$4t+4$	$7t+4$
18, 28, 38, · · ·	$6t+6$	$2t+1$
19, 29, 39, · · ·	$8t+8$	$3t+2$

Example: To find the next to last digit of 37 squared, apply the formula $4t+4$. As 4 times 3 (the tens digit) plus 4 is equal to 16, the terminal digit 6 is the number required because 37 squared is equal to 1369. To find the next to last digit of 37 cubed, apply the formula $7t+4$. Then 7 times 3 plus 4 is equal to 25, and 5 is the required number as 37 cubed is equal to 50,653.

Combining the Formulas with the Digital Process

To illustrate the utility of being able to predict terminal digits of squares, consider an example—again the root 37. What do we know about the square of this number? First, we know that its last digit, because of its seventh position in the series given above in the first paragraph, must be 9. Second, applying the square formula given, $4t+4$, we discover that 6 is the next to last digit. We now have two terminal digits, 69. Third, realizing that 30 squared is 900, we multiply the units digit in 37 times the tens digit and further multiply this product by 2. This final product is added to the 900:

$$\begin{array}{r} 900 \\ 42 \\ \hline 1320 \end{array}.$$

This tells us that the first digit must be 1 (in this case the fact that 37 is close to 40 and that 40 squared is 1600 would also tell us that the first digit cannot be greater than 1). We now have 1?69. Fourth, realizing that the *digital* (the digit obtained by successively adding together the digits of a number until a sum less than 10 is reached) of a square is that digit obtained by finding the digital of its root and squaring it and finding its digital, we add 3+7, find its sum is 10, add 1+0, find its sum is 1, and multiply 1(1) and find its product to be 1. The digital of the square of 37 is therefore 1. Now the digits already obtained are 1?69 and 1+6+9 sums to 16 and has a digital of 1+6 or 7. Hence to obtain the required digital of 1 the missing number 3 must be added because 1+3+6+9 sums to 19 and digitaling 1+9 gives 10, and digitaling 1+0 gives 1.

Take another root, 16. First, the last digit of its square must be 6. Second, according to the formula $2t+3$, the next to last digit must be 5. Third, 10 squared equals 100. Multiplying the units digit in 16 times the tens digit and further multiplying this product by 2, we get 12, and

$$\begin{array}{r} 100 \\ 12 \\ \hline 220 \end{array}.$$

Hence the first digit must be 2 (in this case we know that there cannot be over three digits in the entire square, but let us continue the explanation to show the process of proving by digitaling). Fourth, 1+6 sums to 7. Now 7(7) is 49 which sums to 4+9 or 13, which sums to 1+3, giving a digital of 4. Now the digits already obtained are 256 and 2+5+6 sums to 13 which has a digital of 4. Even had we not

known that the first digit of the square was 2, we would have seen that starting with ?56, 5+6 sums to 11 and has a digital of 2. The missing digit indicated by the question mark would have had to be 2.

Now let us try to find the square of a root that must be of four digits. Try 64. First, the last digit must be 6. Second, according to the formula $8t+1$, the next to last digit must be 9. Third, 60 squared is 3600; the product of the units digit in 64 times the tens digit is 24 and multiplying this by 2, the number 48 is obtained,

$$\begin{array}{r} 3600 \\ 48 \\ \hline 4080 \end{array}.$$

Hence the first digit of the square must be 4. Fourth, we now have the square 4?96, and 4+9+6 sums to 19 which sums to 10 which sums to 1. Since 64 sums to 10 which sums to 1, the missing digit is either 0 or 9. But we know that it must be 0 as 70 squared equals 4900.

These examples and explanations illustrate that the ability to predict terminal digits of squares and cubes is something more than amusing.

EYE ADJUSTMENT CONTROLS CHILD'S READING ABILITY

If Johnny can't read, it may be because his "controlling" eye is on the opposite side of the hand he uses.

Symptoms of poor visual imagery and memory, reversals in reading and writing patterns and mirror writing are then apt to occur. Relief of these symptoms and of stuttering can be accomplished by corrective glasses or limiting hand actions to the corresponding hand.

These findings were cited as among the eye problems of children under 12 by Dr. Owen C. Dickson of the University of California Medical School, Berkeley, at the American Public Health Association meeting.

"Ideally," Dr. Dickson said, "all children should have the benefit of a complete eye examination before school age."

He noted that some eye defects will be so pronounced by the age of five that corrective measures may not succeed. Detection of a tumor, for example, although requiring immediate treatment, is rarely accomplished in school-age children.

Prevention of injuries to the eyes, he said, would include outlawing of B.B. guns in populated areas. Education of parents and the community about the dangers of slingshots, rubber bands, paper clips, scissors, pencils and other sharp objects in children's hands should be stressed.

"Careful handling and placement of liquids, such as cleaning fluids, paints, plant sprays, detergents, drugs and aerosol bombs can prevent many childhood eye injuries, Dr. Dickson stressed.

First aid treatment for any foreign liquid entering the eye should be prompt irrigation with water. The eye can be held open under a faucet, or water can be poured into the eye from a glass.

Dr. Dickson said the use of ointment or eyedrops is to be discouraged because these applications may complicate later care.

The Work of the B.S.C.S. Which May Lead to Content Adjustment on the Horizon*

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Chaucer once described a good teacher by saying—gladly would he learn, and gladly teach." I feel sure you teachers fit this description or you wouldn't be surrendering a rare free day to travel to a convention to hear discussions on the science curriculum.

To speak to you today about the BSCS is both a pleasure and a challenge.

The pleasure stems from having watched the idea of the BSCS take form in the Education Committee of the AIBS, struggle through 18 months of planning, a summer writing conference, and three months of classroom use. Today the BSCS is a thriving vigorous infant. It is hard to keep from showing a pride of kinship to a project which seems destined to leave a permanent mark for the cause of sound biological education.

The challenge for me today is to try to convey to you the stimulation, the enthusiasm, the freshness and the vitality felt by the many thousands of students and hundreds of teachers now using BSCS materials.

The physicists and the chemists for many years have had a strong central organization. The biologists have pursued their professional activities through a host of small scientific societies centered around specific disciplines such as plant physiology, genetics, mycology, et cetera.

A number of these independent societies in 1948 joined together to establish the American Institute of Biological Sciences. Early in its history the AIBS showed great interest in biological education by creating the Committee on Education and Professional Recruitment as its first standing committee. The charge to that committee was a simple one: develop a vigorous program of education at all levels which would become the basic policy of the Institute. Committee membership has been drawn from persons interested in biological education in universities, liberal arts colleges, land grant universities, high schools and preparatory schools .Dr. Oswald Tippo, former chairman of the Botany Dept. at Yale University and now serving as Provost of U. of Colorado, has chaired the committee since its establishment. Some major educational projects which earlier evolved from this committee and which are still in operation include: the Visiting

* A paper presented at the Annual Convention of the Central Association of Science and Mathematics Teachers, Detroit, Michigan, November 24–26, 1960.

Biologists Program for the smaller colleges and high schools, and the Secondary School Biological Sciences Film Series.

The most recent AIBS effort, and one with perhaps the greatest potentiality for the improvement of biological education in America, is the Biological Sciences Curriculum Study. The BSCS began its operations in February, 1959 with initial grants from the National Science Foundation totaling almost $750,000. The Study is national in scope and has established headquarters on the campus of the University of Colorado in Boulder.

The New York *Times* in its editorial, "Teaching Biology" (May 27) put its finger on some of the major difficulties inherent in attempting to revise, upgrade and modernize a course of study.

> "First, it must be determined what knowledge of biology a citizen should have to be literate in the subject, no small accomplishment in itself. Then, the appropriate material from existing high-quality curricula must be earmarked for permanence. And finally, important new developments must be incorporated to weave all aspects together into a coherent, meaningful, and challenging unity."

Dr. Bentley Glass, the chairman of the BSCS Steering Committee, has stated the philosophy and objectives of the BSCS in a manner I would not presume to try to improve upon. Here are his statements.

"In biology much more is involved than updating. Since pre-Sputnik days, the American Institute of Biological Sciences has been concerned with improving not only the subject matter that is being presented under the name of biology at all levels of instruction—from elementary through graduate training—but with the manner of presentation, the emphasis, and the focus.

The Biological Sciences Curriculum Study is an effort to reach workable solutions for these problems. There is no intent by any of the biologists concerned in the curriculum study, whether college teachers or high school teachers, to ignore or change what is presently sound.

The problem, however, is this: In many high schools, the biology taught is primarily hygiene. In others it is primarily animal biology, as demonstrated by a sketchy exposure to invertebrate and vertebrate anatomy. In a great many, the emphasis is on memorization of long lists of scientific names—of structures and categories of organisms, chemical compounds and formal aspects of activities and environment. And, to perhaps the greatest extent of all, biology tends to be presented as a crystallized science, one in which all the answers are known.

When the Biological Sciences Curriculum Study has completed its

work in another three or four years (its activities already have been proceeding for nearly two years), we hope that above all several new approaches will have been found and demonstrated to be praticable in biological instruction. We hope that biology—and indeed, all science—will be revealed in a form which high school pupils can assimilate as an ongoing, never-finished, search for meaning, not as a body of dogma nor taxonomic exercise.

The purpose is not to establish a permanent body of knowledge which will be labeled as standard or definitive. On the contrary, the main objective is to lead each student to conceive of biology as a science, and of all the sciences as tested, reliable methods of gaining objective knowledge. To a very great extent, the key to this understanding lies in laboratory and field study, which scarcely exists in most secondary schools today. For what commonly passes for "lab" is most often a routine conduction of exercises that are no more scientific than following a recipe in a cookbook, or, what is even worse, a mere naming of structures on blank drawings and answering of questions by looking them up in a textbook. Such a travesty of science must be replaced by honest investigation of real scientific problems. For laboratory and field are where science is pursued, where its spirit lives, where its methods are transmitted from one generation to the next. One does not learn science from books, one learns science by asking nature the right questions. And the laboratory is the place where one learns most readily what questions can be asked fruitfully, and how they must be put. It is also the place where one learns why science insists on precision in measurement and accuracy in observation, as well as conciseness and clarity in communication.

As for consideration of the practical by-products of a knowledge of biology, these will not be lessened. Biology has paved the way to a more abundant food supply, to more perfect general health, to a lengthening of the life span, to the preservation of a natural environment that offers man peace and beauty. It has eliminated countless fears and superstitions about disease and death, about heredity and development, race and the future of mankind. It points out the risks we run in our pursuit of comfort and our introduction of the atomic era. It considers the quandaries of human evolution. The man and woman of tomorrow will live in a scientific world which they must understand and adjust to. In fact, if this country is to remain a democracy, citizens must be prepared to govern an economy and a national security tied ever more closely to scientific advancement. To do so will necessitate an understanding of the very real distinction between pure science on the one hand and the "research and development" which takes most of our federal dollars in support of science on the other hand, and will require a real grasp of the dependence of the

latter on the former. Scientific medicine and scientific agriculture become daily more dependent on biological science, and the curriculum should reflect this. But to know the fruit one must know the tree, and to enjoy golden eggs one must nurture the goose. It is our aim to place biological knowledge in its fullest modern perspective.

Dr. Glass concludes by saying—Students of the new biology should acquire not only an intellectual and esthetic appreciation for the complexities of living things and their interrelationships in nature, but also for the ways in which new knowledge is gained and tested, old errors are eliminated, and ever closer approximations to truth are attained."

I am sure many of you here today have participated in the tremendous amount of work which has already gone into the design of the biology curriculum at your state and local levels. Much of this work is good, sound and solid. You might well ask what is the justification then for this new effort and what advantages may accrue from the Study?

It is felt that three points stand out.

1. Today, with financial resources available which were not available even five years ago, it is possible to implement and test the ideas which previously were forced to die on paper.
2. The AIBS, representing 80,000 biologists, is able to keep the professional biological community informed of the progress of the Study. This communication is resulting in a wealth of opinions, suggestions and criticisms being fedback to the Study. Such interaction greatly lessens the danger of imbalance that could more easily develop if the project were associated with a single university.
3. Probably the single most important way in which the BSCS differs from these many independent studies is that the BSCS involves the active participation of a large number of professional biologists who know the life sciences intimately through first-hand investigations. These biologists bring to the new biology curriculum an exhaustive store of modern knowledge, overview and perspective that is available nowhere else in our society.

It should be added here that the BSCS is not creating this new curriculum in the academic image of the professional biologist in an ivory tower on Mt. Olympus, but from the beginning has solicited and used the advice, counsel, work and criticism of the classroom teachers across America in the project.

The enthusiastic reception the BSCS is currently enjoying among

the teachers, and administrators testing the materials, I feel sure is due largely to its usability based on the realistic knowledge of the problems facing the classroom teacher.

Lest you become nauseous from the preceding "sweetness and light," we should realize that schools and teachers tend to be in a rut or well on the way to creating one. This is not necessarily a condemnation of the profession but rather a recognition of its chief occupational hazard. Ruts tend to be comfortable—leaving the rut uncomfortable.

An eminent publisher of scientific texts, speaking to the BSCS Writing Conference this summer, cautioned science teachers to not consider everything they have learned and are teaching as sacred, but rather to examine each piece of material with a critical eye.

The publisher-scientist touched another nerve when he pointed out that "much of the present teaching of science is essentially a didactic one. We expect people to memorize and not analyze and have not expected growth in mental capacity as well as memory. A static didactic approach is inappropriate in science and we should think seriously about this problem. As far as controversial issues are concerned, authors often feel they should be left out of a book, but this is the type of thing that should be put in to show that there are still problems to be solved."

The publisher also touched on another point and one which the BSCS has tried valiantly to incorporate in the preparation of its text materials. It is that the core of a program such as this should be a selection of the important concepts, and relatively few of them. This means discarding much of the material, mostly factual, included in the traditional high school biology course—a very painful procedure I might add. Having picked out the concepts the next problem is to pick the facts necessary to build around these concepts. As the facts are built into the concepts they become more meaningful.

In short ladies and gentlemen, as we move toward the horizon we must, to quote the poet Gray, give our students "thoughts that breathe and words that burn."

"LIVING LIGHT" CHEMICAL CRYSTALLIZED FROM GLOWING FISH

The "living light" chemical, luciferin, which makes a glowworm glow, has been crystallized from a glowing South Pacific fish known in Japan as kinme modoki by a Princeton biologist and two Japanese colleagues.

Dr. Frank Harris Johnson, biology professor, and Dr. Yata Haneda of Tokyo's Jikeika Medical College separated kinme modoki luciferin compound in 1957 in Japan.

Science News in High School Science Classes

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From the advent of modern approaches to science education in the 1920's there has been a continuing interest in the use of science news in the classroom. Van Deventer (1957)[1] published a comprehensive bibliography of articles based on studies of this problem. The present study was carried on by the writer as a part of his graduate program at Western Michigan University, utilizing his high school classes at Grand Haven, Michigan, as an educational laboratory. Time was spent in several science classes in creating and finding ideas that would integrate recent science developments with the regular science program in such a way as to supplement and strengthen the science course. It is hoped that other teachers may benefit from the experiences of the writer. This paper is not intended to describe a step-by-step teaching unit, but rather to indicate ideas and methods which can be utilized by a variety of classes and levels. These ideas and techniques should be adjusted to the interest area and age level of each class.

Many science teachers feel that recent developments in science should be taught as a part of the regular science program. These developments are an outgrowth of the science principles, attitudes and methods which we teach in our science classes. Science news furnishes a challenge to the teacher to pass the "textbook barrier," and to promote an understanding of the larger concepts and wider views of science. This objective can be accomplished by using current science news articles as part of the foundation of a high school course.

A recent survey shows a growing desire for the inclusion of more science articles in newpapers and magazines. Two out of three readers would like to see more science news at the expense of other news.[2] Other studies show that in one year after Sputnik I was launched, science stories in newspapers increased by 50%.[3] Most editors now recognize a high interest in satellites and outer space, medicine, public health and atomic energy. Science news is gaining in importance in newspapers and magazines.

We can anticipate a continued increase in the number of science articles, as well as an attempt to produce and publish more accurate and better detailed ones. In such a situation teachers face problems in building a sustained level of serious reading habits in their students.

[1] Van Deventer, W. C., "Educational Values of Science-in-the-News." School Science and Mathematics LVII (December, 1957), 673–681.

[2] ———, "Newspaper Readers Want More Science News." *Science News Letter* (August, 1958), 120.

[3] Kriegbaum, H., "Public Interest in Science News." *Science* CXXIX (April, 1959), 1092–1095.

Students may learn how reading relates to their lives today, and how it will relate even more directly to their after-school futures.

Materials Needed for a Science-in-the-News Unit

In setting up a teaching unit for science-in-the-news, each student should be required to purchase a basic periodical chosen by the teacher. Following is a list of the periodicals used in the author's classes:

Current Science (Weekly)..... .70¢ per school year.
Science World (Bi-Weekly).....$1.50 per school year.
Science Digest (Monthly)..... .25¢ per copy.

Two or more students can share the periodicals, thus cutting the cost per pupil.

The school should supply three or four newspapers and magazines of a conservatively edited type. Newspapers vary widely in science content and treatment; therefore the teacher should be discreet in his selection. The writer has found the *New York Times*, and two local papers, the *Muskegon Chronicle* and the *Grand Haven Daily Tribune*, very satisfactory for class use.

Many general news and review magazines lend themselves to a project of this type. The writer has found the following magazines to be acceptable for high school students: *Science Digest*, *Science News Letter*, *Time* and *Newsweek*. In addition, *Scientific American* is useful for accelerated students.

Techniques and Procedures

The procedure must necessarily vary widely according to age level and even according to individual classes. Through much experimentation the author has found it necessary and desirable to change the approach and activities frequently even in working continuously with the same class. This serves to prevent loss of interest on the part of students and appeals to individuals of varying interests and ability levels.

Monday was usually set aside for "science-in-the-news day." The first ten or fifteen minutes were usually spent in reading the periodicals which the students had purchased. Following this we often had a free period in which students read science articles in the latest magazines and newpapers which were provided by the school. During this period, also, students often prepared summaries of science articles from available sources.

After the free reading period, some type of further science news activity was carried on. The writer tried many activities. Some were successful and some were failures. Those which succeeded were used

again. Those which did not succeed were discarded. A list of those activities which proved most worthwhile follows:

1. After the reading period ask each student to give a short oral report on the most interesting article he has read. This furnishes a good opportunity for initiating discussion.

2. Ask each student to turn in a written report on a science article telling the "Who?" "What?" "When?" "Where?" and "Why?" of it. Have the class see that the main thought is in the title and first paragraph, and that succeeding material is supplementary. Have them recognize that there is sometimes a summary at the end of the article.

3. Cut out enough science articles to pass around to each member of the class. Clip off the title and have the students make up their own title or headline. Have them read their title to the class and compare it with the real one. This helps the students to differentiate between the important material and that which is less important.

4. Have the class interview reporters or other newpaper workers in the classroom. Here students can find out what science news is, how they anticipate news, how reporters are restricted to writing articles that are readable, and how they are restricted to the use of words that can be understood by the general public. Usually the reporters who visit the classroom are surprised by the students' interest in and critical attitude toward science news articles.

5. A good follow-up of such an interview is to visit the newspaper plant. There is an interest on the part of students as to how news from all over the world can converge into one office and become a part of the local newspaper. This is more sophisticated than a field trip to see the paper "run."

6. Some time may be spent in writing science articles for the school or local papers. A class might function well enough to be able to make up an entire newspaper by themselves. In this case someone from the newspaper staff may be asked to explain to the students how to set up a "dummy" copy.

7. Some time may be spent by each student on the preparation of a report based on a more comprehensive science article. Magazines are a good source for such research. In this report students should be encouraged to include graphs, charts, diagrams, et cetera. The student should be allowed to pick his own subject and source.

8. Better students may undertake to measure the column inches devoted to science in different newspapers. These data from newspapers of different types can then be compared. A simple graph on the blackboard will help in making the comparison.

9. By using a radio in the classroom, students may listen to news reports in cases where science news is included. The students may

then evaluate and discuss these reports and compare this news with news from other media.

10. In the case of a science news story of general interest some time may be spent comparing what different newspapers have done with the same topic. In such case the factual account published in *Science News Letter* can usually be used as a standard for comparison.

11. An up-to-date bulletin board of science news can be kept. Students can be encouraged to bring pictures and articles.

12. Students may be asked to look up back issues of magazines for pertinent science articles in order to compare the old with the recent in science and technology. For example, a 1930 aircraft may be compared with modern jets and rockets. Conservation in 1920 may be compared with conservation in 1960.

13. Some students may like to make a scrapbook. This scrapbook may be divided into major science areas. A table of contents should be made for each section.

14. Some time should be spent in making a vocabulary of scientific terms that the students often see but do not understand. Each student should be asked to make a glossary of such terms drawn from his reading.

15. Each student may be given a copy of a newspaper together with a mimeographed sheet with questions such as these:

(a) Do the headlines fit the stories, or do they exaggerate or mislead?

(b) From what news service does this paper get its news?

(c) How much area is given to science? Estimate totals and calculate the percentages.

Have the student rate the paper as good, fair, or poor and give reasons.

16. A panel discussion may be held concerning controversial areas such as: Should we try to control human population? Is there such a thing as an "abominable snowman"?

17. Students may be asked to find misleading advertisements in magazines and newspapers. They may write papers listing the advertising claims with their own criticisms. They should give the basis for their criticisms. If there is time, at the end of the period, some of these papers can be read to the class.

18. If students find science maps, charts, or diagrams which are of special interest, these can be drawn on the board and discussed.

19. Students may be asked to prepare oral reports showing why a certain science news article is well written.

20. Several science articles may be read to the class. The students may then be asked to write a headline for each article. The headline may be criticized and discussed.

21. On a large world map, small typewritten notes may be pinned showing special science happenings such as:

(a) new mineral discoveries.

(b) the path of an eclipse.

(c) the whereabouts of current scientific expeditions.

22. Members of the class may be given opportunities to practice the skills of classifying and organizing references to science articles in magazines and pamphlets. Such a bibliography may be useful to the teacher.

23. Occasional two-week projects may be given in which students will prepare written reports on science articles dealing with a particular topic. They may get the articles at home or at school. During science-in-the-news days they can glean and summarize information from materials in the room. This is an absorbing experience for the students if it is not done too often. The writer would suggest two or three times a semester for high school students. Following is a list of rules which were very helpful in this study:

(a) The written report of each science article should be in the form of a *brief* summary. In many cases the first paragraph of the article will be sufficient.

(b) The date and source of the article should be listed.

(c) The articles should be classified in a chronological order.

(d) The reports should be done accurately and in a workmanlike manner.

(e) The articles should be graded for quality as well as quantity.

(f) Credit should not be given for pictures or clippings inserted into the report.

(g) Criticism of articles should be encouraged by giving honor points to those who find mistakes, unreliability, contradictory statements, unjustified inferences, et cetera.

Incidental Values of Science-in-the-News and Suggestions For Its Use

A valuable library of periodicals can be built up over the years by saving complete series of magazines and filing them. This will give unlimited possibilities for supplementing the entire science course.

Some magazines publish indices from time to time. These should be filed in a manila folder and made available to the students.

A three-by-five card may be prepared for each topic that belongs in your course of study. Notes may be made on the cards indicating any special use or reference.

The school library may be asked for any available copies of old periodicals which deal with science. It may be desirable to have some series of magazines bound. Bound volumes of such magazines as

Science News Letter and *Current Science* take up little space and are invaluable for classroom use.

An incidental value of a unit of study of this type is to encourage students to use the library. Their enthusiasm for this study will help to motivate their learning their way around the library.

After the classroom library is built up, it may be worthwhile to buy *The Readers Guide to Periodical Literature* if it is not otherwise available. The city library will usually be glad to cooperate by furnishing a list of their periodicals. This list may then be posted where students can use it.

Most people have to spend a great deal of time and effort to master even a small branch of science. Today through newspapers and magazines many are finding that science can be a pleasure. Those leaving school are influenced tremendously by these media. This will be their main reading diet. Our students should learn to read and evaluate such materials. They should become critical (not gullible) and develop understanding. Let them discover, as they must, that science is more than stated principles and experiments from a textbook. Through science-in-the-news they will discover that science is thrilling, dynamic and vital. They will find that science is not a magic wand or an ivory tower. They will get insights into the interrelationships of the various sciences. New doors will be opened that will expose a new frontier of education.

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LIFE IS LIKELY THE SAME ANYWHERE IN THE UNIVERSE

Life is likely to be the same anywhere in the universe because all living organisms are most probably made up of the same four elements: carbon, oxygen, nitrogen and hydrogen.

Only these four elements have the suitable properties for sustaining life, Dr. George Wald, biology professor at Harvard University, told the American Philosophical Society.

He said that it is doubtful if life can arise without water or progress very far without oxygen. Nor is it likely that life can exist anywhere without radiation—such as the radiation the earth receives from the sun that excites molecules electronically and so activates photochemical reactions.

Therefore, it is possible to consider universal physical relationships, Dr. Wald said. The relationships in the periodic system of the elements may be assumed true everywhere in the universe; so also the laws of chemical combinations and dissolution; and the effects of temperature, pressure and radiation on the rates of chemical reaction.

NEW TOOL TRACKS LIGHTNING, HURRICANES AND TORNADOES

A new tool that can pick up static from lightning storms, tornadoes and hurricanes with greater accuracy has been developed at the National Bureau of Standards, Boulder Laboratories.

The system, named "Ephi," consists of three 125-foot antenna towers, four miles apart, and a central control station, located in an old schoolhouse near Brighton, Colo.

The three antenna poles form a triangle, and when a storm occurs, the sferic, or static, radio signals reach each antenna at a slightly different time, except when a storm occurs at the exact center of the triangle. From the antennas the signals are sent to the central control station where electronic equipment determines the direction to the lightning source.

Ephi can also count the number of static signals arriving from several different directions at the same time. In addition, the sferic waveform on an oscilloscope can be photographed either with still or movie cameras for studies aimed at a better understanding of radio wave propagation and the nature of lightning.

For tracking tornadoes and hurricanes, two stations like the one just installed could determine the position of a storm at distances of many hundreds of miles from either station.

The Teaching of Directed Numbers and the Postulates of Abelian Groups

Edward J. Zoll

Department of Mathematics, Newark State College, Union, New Jersey

One ninth grade algebra class from each of the four high schools in Levittown, New York, was designated as an experimental class during the school year 1959–60. These experimental classes studied the postulates of groups in place of the usual introductory topics of literal representation, simple equation—solving, and formula-evaluation. Among the purposes for the use of groups as an introduction to algebra were: (1) to introduce the student to postulational reasoning, and (2) to suggest an explanation of the rules for operating with directed numbers.

When the classes were capable of constructing and identifying groups, their attention was directed to the set of natural numbers and the operation of addition. Addition in this set was closed, associative, and commutative. The natural numbers, however, did not form a group for addition.

One class volunteered "0" as the identity element and starred numbers as inverse elements for addition. Thus, the additive inverse of 4 was written as 4*.

Table 1 shows some of the natural numbers, the identity element, and the additive inverse elements.

TABLE 1

+	1	2	3	0	1*	2*	3*
1	2	3	4				
2	3	4	5				
3	4	5	6				
0							
1*							
2*							
3*							

The upper portion within the table has been entered to indicate the previously accepted addition facts. The problem that now faced the classes was how to complete Table 1.

Since "0" was the identity element, and since addition was to remain commutative, Table 1 became

TABLE 2

+	1	2	3	0	1*	2*	3*
1	2	3	4	1			
2	3	4	5	2			
3	4	5	6	3			
0	1	2	3	0	1*	2*	3*
1*				1*			
2*				2*			
3*				3*			

Because an element and its additive inverse produce the identity element for the operation of addition, (1+1*), (2+2*), and (3+3*) were entered as zero in Table 2 to produce Table 3.

TABLE 3

+	1	2	3	0	1*	2*	3*
1	2	3	4	1	0		
2	3	4	5	2		0	
3	4	5	6	3			0
0	1	2	3	0	1*	2*	3*
1*	0			1*			
2*		0		2*			
3*			0	3*			

Before the remainder of Table 3 could be defined, it was necessary to investigate a property of Abelian groups that the students had not previously studied.

TABLE 4

$\frac{\#}{\#}$	*A*	*B*	*C*	*D*
A	*A*	*B*	*C*	*D*
B	*B*	*C*	*D*	*A*
C	*C*	*D*	*A*	*B*
D	*D*	*A*	*B*	*C*

Since *A* is the identity element in Table 4, it follows that *B* is the inverse element of *D*, *C* and *A* are their own inverse elements and *D* is the inverse element of *B*. If the star symbol from Tables 1–3 was used, then

$$A^* = A$$
$$B^* = D$$
$$C^* = C$$
$$D^* = B$$

The problem was, how was one to evaluate

$$(B^*) \# (D^*)?$$

Students invariably suggested that one *convert* the inverse elements to the respective element *and* then *perform* the operation.

Thus, $(B^*) \# (D^*)$ became $D \# B$ or the element A. When the students were requested to find another method of evaluating $(B^*) \# (D^*)$, many suggested *performing* the operation *and* then *converting* as:

$$(B^*) \# (D^*) = (B \# D)^*$$
$$= A^*$$
$$= A$$

Other Abelian Groups were investigated in order to gain partial support for the theorem: (Inv. El. K) op. (Inv. El. M) = Inv. El. (K op. M). When this was accepted, it was possible to enlarge Table 3 as:

TABLE 5

+	1	2	3	0	1*	2*	3*
1	2	3	4	1	0		
2	3	4	5	2		0	
3	4	5	6	3			0
0	1	2	3	0	1*	2*	3*
1*	0			1*	2*	3*	4*
2*		0		2*	3*	4*	5*
3*			0	3*	4*	5*	6*

By the theorem 1^*+2^* was the same as $(1+2)^*$ or 3^*.

The remainder of the table was completed by use of the postulates of groups and the definitions. For example,

$$1+3^* = 1+(1+2)^* \quad \text{(Table)}$$
$$= 1+(1^*+2^*) \quad \text{(Theorem)}$$
$$= (1+1^*)+2^* \quad \text{(Associativity)}$$
$$= 0+2^* \quad \text{(Additive Inverse)}$$
$$= 2^* \quad \text{(Identity)}$$

After the teachers introduced the conventional symbol for the additive inverse of a number, students were asked to "solve" problems such as:

Steps	*Postulates or Definitions*
$(-18)+(27)$	
$(-18)+(18+9)$	(Addition Table)
$(-18+18)+9$	(Associativity)
$0+9$	(Element and its additive inverse)
9	

Steps	*Postulates*
$(-20)(14)=(-14+(-6))+14$	(Addition Table)
$=(-6+-14)+14$	(Commutativity)
$=(-6)+(-14+14)$	(Associativity)
$=-6+0$	(Element & Inverse)
$=-6$	

It was interesting to note that a student pointed out that the relationship

$$(-A)+(-B)=-(AB)$$

could be used to explain the rule for finding the product of two fractions, as:

$$\tfrac{1}{2}\times\tfrac{1}{3}=\tfrac{1}{6}$$

The use of the postulates of an Abelian group in the teaching of directed numbers afforded students some experience with postulational thinking, as they (a) postulated the existence of directed numbers, (b) did not accept "relationships" for all systems, and (c) used postulates in working with additive inverse elements.

The results of testing and comparing these students with those students who were taught directed numbers in the usual manner indicated that (a) students in the modern classes of average or above-average I.Q. (105 and above) made fewer errors than students in the traditional classes, and (b) students in the experimental classes whose I.Q. scores were lower than 105 made the same number of errors as did the students with similar I.Q. scores in the traditional classes. When tested on the modern material only, students in the modern classes whose I.Q. scores were lower than 105 scored the same as did students in the modern classes whose I.Q. scores were 105 or above. Students in the traditional courses were not tested on modern materials.

EARTH'S MAGNETIC FIELD CAUSES SPACE FLIGHT HAZARD

The direct influence of the earth's magnetic field on space travel is negligible, but indirectly the geomagnetic field is responsible for the greatest hazard of manned space flight, the dangerous Van Allen belts of radiation.

The trapping of the high energy particles by the geomagnetic field in the Van Allen belts causes a danger area to man in space because of radiation.

The screening effect of the magnetic field affords a natural protection from this radiation.

Problem Department

Conducted by **Margaret F. Willerding**

San Diego College, San Diego, Calif.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problem should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem sent the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the Department desires to serve her readers by making it interesting and helpful to them. Address suggestions and problems to Margaret F. Willerding, San Diego State College, San Diego, Calif.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Solutions should be in typed form, double spaced.

2. Drawings in India ink should be on a separate page from the solution.

3. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

4. In general when several solutions are correct, the one submitted in the best form will be used.

2743. *Proposed by C. W. Trigg, Los Angeles City College.*

Find the smallest pair of consecutive integers, each of which can be expressed as the sum of two cubes.

Solution by the Proposer

By determining the sum of all pairs which can be formed from the cubes of the numbers from 1 to 10, we find that

$$5^3+9^3=854 \quad \text{and} \quad 7^3+8^3=855$$

are the smallest consecutive integers each of which can be expressed as the sum of two cubes.

A solution was also offered by Walter H. Carnahan, Madison, Ind.

2744. *Proposed by Lowell Van Tassel, San Diego, Calif.*

Here is a probability problem that was suggested by a recent promotional stunt for *Time* magazine. It seems that every month, for the next 12 months, a small postcard-sized picture of a former MAN OF THE YEAR will be enclosed with the magazine on a random basis. (This will happen only once a month even though *Time* is published weekly.) Problem: What are the odds on collecting a complete 12 man set in the next year?

Solution by the Proposer

For the 1st month, any card will do

$$\Pr\left\{\begin{matrix}\text{new}\\ \text{card}\end{matrix}\right\}=\frac{12}{12}=1.$$

For the 2nd month, only 11 of 12 possible will do

$$\Pr\left\{\begin{matrix}\text{new}\\ \text{card}\end{matrix}\right\}=\frac{11}{12}.$$

For the 3rd month, only 10 of 12, etc.

$$\Pr\left\{\begin{matrix}\text{new}\\ \text{card}\end{matrix}\right\}=\frac{10}{12}\quad\text{etc.}$$

$$\Pr\left\{\begin{matrix}\text{All 12}\\ \text{distinct cards}\end{matrix}\right\}=\frac{12}{12}\cdot\frac{11}{12}\cdot\frac{10}{12}\cdot\frac{9}{12}\cdots\frac{3}{12}\cdot\frac{2}{12}\cdot\frac{1}{12}$$

$$=\frac{12!}{12^{12}}\equiv Q$$

$\log 12!$	$18.68034-10$
$\log (12)^{12}$	12.95017
$\log Q$	$5.73017-10$

$$Q=5.3724\times10^{-6}.$$

Reciprocal of $Q\approx\dfrac{1}{18{,}613}$ *Time's* odds as given in "Letter from Publisher" Section.

2745. *Proposed by John Satterly, University of Toronto.*

Prove that the center of gravity of three masses proportional to sin $2A$, sin $2B$, sin $2C$ placed at the vertices A, B, C respectively of a triangle ABC is at the circumcenter.

Solution by Walter R. Talbot, Jefferson City, Mo.

I. It is assumed that the traingle is non-oblique so as to place the circumcenter on or in the triangle. There is no loss of generality in assuming the triangle to be in the position $A(0, 0)$, $B(c=p+u, 0)$, $C(p, h)$ where the altitude from C divides AB into the segments p and u. Let $AC=q$ and $BC=v$. $\sin A=h/q$, $\cos A=p/q$, $\sin B=h/v$, $\cos B=u/v$. By Law of Sines $\sin C=ch/qv$ and by the formula for the cosine of the sum of two angles $\cos C=(h^2-up)/qv$. Then $\sin 2A=2hp/q^2$, $\sin 2B=2hu/v^2$, $\sin 2C=2hc(h^2-up)/(qv)^2$.

II. For subsequent convenience we notice that $\sin 2A+\sin 2B+\sin 2C=2h(pv^2+uq^2+ch^2-cup)/(qv)^2$. Substituting h^2+u^2 for v^2, h^2+p^2 for q^2, and then collecting $p+u$ into c, we get

$$\sin 2A+\sin 2B+\sin 2C=4h^2c/(qv)^2.$$

By similar procedures we find

$$c\sin 2B+p\sin 2C=2h^2c^2/(qv)^2$$

and

$$h\sin 2C=2h^2c(h^2-up)/(qv)^2.$$

III. Let the center of gravity be $G(k, m)$. There is no rotation about a line through G; so we compute the moments about a vertical line $x=k$ and about a horizontal line $y=m$.

For $x=k$

$$k\sin 2A=(c-k)\sin 2B+(p-k)\sin 2C.$$

For $y=m$

$$m\sin 2A+m\sin 2B=(h-m)\sin 2C.$$

Then

$$k=(c\sin 2B+p\sin 2C)/(\sin 2A+\sin 2B+\sin 2C)=2h^2c^2/4h^2c=c/2.$$

$$m=h\sin 2C/(\sin 2A+\sin 2B+\sin 2C)=2h^2c(h^2-up)/4h^2c=(h^2-up)/2h.$$

IV. It remains to be shown that m is the ordinate for the circumcenter. The slope of AC is h/p and the midpoint of AC is $(p/2, h/2)$. Then the perpendicular bi-

sector of AC is $2hy+2px-h^2-p^2=0$. This meets the perpendicular bisector of AB, $x=c/2$, in $y=(h^2-up)/2h$ which is m.

A solution was also offered by the proposer.

2746. *Proposed by D. Moody Bailey, Princeton, W. Va.*

Problem. p is any point in the plane of triangle ABC through which cevians are drawn from A, B, and C meeting the opposite sides at points D, E, and F respectively. M is the midpoint of side BC and MP is constructed meeting CA at N and AB at O. Show that

$$\text{(a) } \frac{AO}{OB}+\frac{AF}{FB}=\frac{AE}{EC} \quad \text{and} \quad \text{(b) } \frac{AN}{NC}=\frac{AE}{EC}-\frac{AF}{FB}$$

where all segments are considered as directed quantities.

Solution by the Proposer

Considering triangle ABC and transversal $MPON$, we use the theorem of Menelaus and have

$$\frac{BM}{MC}\cdot\frac{CN}{NA}\cdot\frac{AO}{OB}=-1.$$

Since BM/MC equals unity this expression becomes

$$\frac{CN}{NA}\cdot\frac{AO}{OB}=-1 \quad \text{or} \quad \text{(1) } \frac{CN}{NA}=-\frac{BO}{OA}.$$

Since NO passes through P, the point of intersection of cevians BE and CF, we next use "A Triangle Theorem" discussed in the April, 1960 issue of SCHOOL SCIENCE AND MATHEMATICS. This gives

$$\text{(2)} \qquad \frac{AF}{FB}\cdot\frac{BO}{OA}+\frac{AE}{EC}\cdot\frac{CN}{NA}=1$$

and we substitute from (1) in this equation obtaining

$$\frac{AF}{FB}\cdot\frac{BO}{OA}-\frac{AE}{EC}\cdot\frac{BO}{OA}=1.$$

Thus,

$$\frac{BO}{OA}\left(\frac{AF}{FB}-\frac{AE}{EC}\right)=1 \quad \text{or} \quad \text{(a) } \frac{AO}{OB}=\frac{AF}{FB}-\frac{AE}{EC}.$$

In the light of (1) we may replace

$$\frac{BO}{OA} \quad \text{by} \quad -\frac{CN}{NA}$$

in equation (2) and after solving have

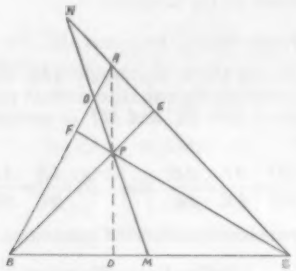
$$\text{(b)} \qquad \frac{AN}{NC}=\frac{AE}{EC}-\frac{AF}{FB}.$$

The theorem of Menelaus and equation (2) are true when all segments involved are considered as directed quantities. Therefore the results secured in (a) and (b) must be true under the same conditions. So if F and O lie between A and B the ratios

$$\frac{AF}{FB} \quad \text{and} \quad \frac{AO}{OB}$$

must be considered positive. If either F or O lie exterior to AB the corresponding

ratio or ratios must be considered negative. Similarly for points E and N on side CA.



2747. *Proposed by Thomas R. Curry, Oyster Bay, N. Y.*

There exists a number $abcd$ such that $(ab+cd)^2$ $abcd$. Find the number.

Solution by C. W. Trigg, Los Angeles City College

This is the same as problem 2708, a solution to which was published on page 408 of the May 1960 issue. There it was shown that $abcd = 2025$, 3025, and 9801.

Also, in the decimal system, the solution of $ab=(a+b)^2$ is 81. The solutions of $abcdef=(abc+def)^2$ are 494209 and 998001. Indeed, since $(10^k-1)^2=10^{2k}-2.10^k+1$, any number in which an 8 is preceded by n 9's and is followed by n 0's and a 1 fits the pattern.

In other scales of notation, the solutions of $(ab+cd)^2=abcd$, are:

Base	*abcd*
2	1001
3	2101
4	1210, 3201
5	2011, 4301
6	1013, 2013, 5401
7	3114, 6501
8	1420, 2420, 7601
9	5714, 8701
11	1225, 4*X*25, 6*X*19, *X*901
12	2630, 3630, ϵ*X*01

In fact, since $R-1$ $R-2+01=R-1$ $R-1=R(R-1)+(R-1)=R^2-1$, it follows that in any system of numeration with base R, a solution is $R-1$ $R-2$ 01. There seems to be no justification for considering 0001 to be a solution.

Solutions were also offered by P. Steveson, Greenville, S. C.; and the proposer.

2648. *Proposed by C. W. Trigg, Los Angeles, Calif.*

In the scale of six,

$$TIRES=(TEE)^2 \quad \text{and} \quad IREST=(EET)^2.$$

Find the digits which are uniquely represented by the letters.

Solution by Mathematics Club, Allegheny High School, Pittsburgh, Pa.

Obviously neither T nor E is 0.

In the scale of six, $1^2=1$, $2^2=4$, $3^2=13$, $4^2=24$, and $5^2=41$.

Since $(TEE)^2$ has the last digit S and $(EET)^2$ has the last digit T, E may be 2 or 5; T may be 1, 3, or 4.

If E is 2, for $(TEE)^2$ we obtain * * * 2 4 and for the E in *TIRES* we find a 2.
If E is 5, for $(TEE)^2$ we obtain * * * 0 1 and for the E in *TIRES* we find a 0.
Thus E can not be 5 and must be 2.
With $E=2$ and $T=1$, we find $(122)^2=15324$ and assign values $T=1$, $E=2$, $R=3$, $S=4$, and $I=5$.
For $(EET)^2=(221)^2$ we get 53241 and the values represented by the letters agree with those assigned above.
Since $3^2=13$ and $4^2=24$, $(TEE)^2$ would have six digits and so $T\neq 3$ or 4.

Solutions were also offered by P. Brown, Chicago, Ill.; P. Stevenson, Greenville, S. C.; Walter R. Talbot, Jefferson City, Mo.; and the proposer.

S-6. Proposed by Lee H. Mitchell, Ann Arbor, Mich.

Given that a, b, c, and d are in harmonic progression and that $(a+b)/(c+d)=1$. Find a/b and c/d.

Solution by Martin Saul Hoffman, Boston Latin School, Boston, Mass.

By definition, since a, b, c, and d are in harmonic progression, their reciprocals are in arithmetic progression. Let us denote

(1) $1/a=x$, then $a=1/x$.

(2) $1/b=x+y$, then $b=1/x+y$.

(3) $1/c=x+2y$, then $c=1/x+2y$.

(4) $1/d=x+3y$, then $d=1/x+3y$.

Also $a+b=c+d$ or $1/x+1/(x+y)=1/(x+2y)+1/(x+3y)$. This gives

$$1/x-1/(x+2y)=1/(x+3y)-1/(x+y) \quad \text{or} \quad 2y/x(x+2y)=-2y/(x+y)(x+3y).$$

Hence either $y=0$ or $x(x+2y)+(x+y)(x+3y)=0$.
In the first case, $a/b=c/d=1$. In the latter case, we get $3y^2+6xy+2x^2=0$ or $y/x=(-3\pm\sqrt{3})/3$. Now using these results and substituting in (1)–(4) we get

(5) $a/b=1+y/x=\sqrt{3}/3$ or $-\sqrt{3}/3$.

(6) $c/d=(x+3y)/(x+2y)=1+(y/x)/[1+2(y/x)]=-\sqrt{3}$ or $\sqrt{3}$.

S-7. Proposed by Harry Frye, Tullahoma, Tenn.

Find the greatest area of an integral right triangle whose hypotenuse is 325.

Solution by Martin Hoffman, Boston Latin School, Boston, Mass.

The general solution for $a^2+b^2=c^2$ is $a=2tmn$ $b=t(m^2-n^2)$, and $c=t(m^2+n^2)$.
Then $c=t(m^2+n^2)325$. Hence t is an intregal divisor of 325, or $t=1$, 5, 13, 25, 65, or 325.
Then

(1) $t=1$, $m^2+n^2=325$.

(2) $t=5$, $m^2+n^2=65$.

(3) $t=13$, $m^2+n^2=25$.

(4) $t=25$, $m^2+n^2=13$.

(5) $t=65$, $m^2+n^2=5$.

(6) $t=325$, $m^2+n^2=1$.

These have the solutions

(1) (1, 18); (6, 17); (10, 15).

(2) (1, 8); (4, 7).

(3) (0, 5); (3, 4).

(4) (2, 3).

(5) (1, 2).

(6) (0, 1).

From this, the intregal solutions are given with their areas as;

(1i) (36, 323, 325). 5, 814

(1ii) (204, 253, 325). 25, 806

(1iii)	(300, 125, 325).	18, 750
(2i)	(80, 315, 325).	12, 600
(2ii)	(280, 165, 325).	23, 100
(3i)	(0, 325, 325).	00
(3iii)	(312, 91, 325).	14, 196
(4i)	(300, 125, 325).	18, 750
(5i)	(260, 195, 325).	25, 350
(6i)	(0, 325, 325).	00

From this it appears that the intregal right triangle with the maximum area is the one with sides 204, 253, 325 and with an area of 25,806.

S-8. *Proposed by Lee Mitchell, Glencoe, Ill.*

Prove that sin $2nx$ has the factor 2 sin x cos x, where n is an integer.

Solution by Martin Saul Hoffman, Boston Latin School, Boston, Mass.

2 sin x cos x = sin $2x$ by identity. Hence the truth for $n=1$ is immediately established.

By mathematical induction, assume that sin $2nx$ is divisible by sin $2x$ for $n=m$ and prove that this holds for $n=m+1$.

Then sin $2(m+1)x$ = sin $(2mx+2x)$ = sin $2mx$ cos $2x$ + cos $2mx$ sin $2x$. Now by hypothesis sin $2mx$ has the factor sin $2x$, hence sin $2x$ divides both products on the right and therefore sin $2(m+1)x$.

Then the above is true for $n=1$, and therefore for $n=2$. Since it is good for $n=2$, it is good for $n=3$. Since it is good for $n=3$, it is good for $n=4$, and so on ad infinitum.

Following the same lines of reasoning as given above, one can prove that sin anx has the factor sin ax when a is specified, as 2, and n is any integer.

STUDENT HONOR ROLL

The Editor will be very happy to make special mention of classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

Editor's Note: For a time each student contributor will receive a copy of the magazine in which his name appears.

The Student Honor Roll for this issue appears below.

S-1, *S*-4, *S*-5, *S*-6, *S*-7, *S*-8, 2731, 2747. *Martin Saul Hoffman, Boston Latin School, Boston, Mass.*

2743. *Laurence J. Marten, Los Angeles, Calif.*

2748. *Barbara Jannusch, Chicago, Ill.*

PROBLEMS FOR SOLUTION

2767. *Proposed by Walter H. Carnahan, Madison, Wis.*

Find the smallest pair of consecutive odd integers each of which is the difference of two cube integers.

2768. *Proposed by C. W. Trigg, Los Angeles, City College.*

A uniform ladder rests against a vertical wall, to which it is inclined at an angle of 45°. The coefficients of friction of the wall and of the ground are respectively $\frac{1}{3}$ and $\frac{1}{2}$. A man climbs up the ladder and just gets to the top as the ladder starts to slip. What are the relative weights of the man and the ladder?

2769. *Proposed by Brother Felix John, Philadelphia, Pa.*

Determine a formula for the sum of the products of every pair of the squares of the first n whole numbers.

2770. *Proposed by Donald R. Byrkit, West Chicago, Ill.*

In the game of $X(30 \leqq X \leqq 40)$ one die is used. First player throws the die. Second player gives the die a quarter turn adding number turned to number shown. First player then gives the die another quarter turn adding number turned to total already reached. A player wins by reaching exactly X or by forcing his opponent to exceed X on his turn of play. One value only of X gives the second player an absolute win. What is this value? How does the second player play in order to guarantee a win?

2771. *Proposed by Barry Kolb, Chicago, Ill.*

Prove in any triangle ABC,

$$(a+b-c)/2c = \lim_{n\to\infty} \sum_{k=1}^{n} (\tan \tfrac{1}{2}A \tan \tfrac{1}{2}b)^k$$

2772. *Taken from MORE PROBLEMATICAL RECREATIONS*

Using only mathematical signs and without changing the position of any of the figures, can you make this into an equation?

2 9 6 7=17.

Books and Teaching Aids Received

SCIENCE TODAY SERIES. All cloth. All 11.5×18 cm. All $1.75 per book. 1960. Harper & Brothers Publishers, 49 East 33rd Street, New York 16, N. Y.

THE ANATOMY OF PLANTS, by P. Font Quer *formerly, Professor of Botany and Director of the Botanical Institute Barcelona*. 128 pages.

MATTER AND ANTIMATTER, by Maurice Duquesne, *Director of Research in Nuclear Physics at the Radium Institute, Paris*. 127 pages.

INTELLIGENCE: ITS EVOLUTION AND FORMS, by Gaston Viaud, *Professor of Psychology and Director of the Laboratory of Animal Psychology Strasbourg*. 127 pages.

THE WIDER UNIVERSE, by Paul Couderc. 128 pages.

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Book Reviews

THE SCIENTIFIC AMERICAN BOOK OF PROJECTS FOR THE AMATEUR SCIENTIST, by C. L. Stong. Cloth. 13×21 cm. 1960. Simon and Schuster Publishers, 630 Fifth Avenue, Rockefeller Center, New York 20, New York. Price $5.95.

This book, as the title implies, contains projects for the "amateur scientist." However, it is not just another list of trivial "experiments" with which most science teachers and students are familiar. Instead, there are challenging projects in various areas of science that will arouse interest of both teachers and students. There are: eight projects in astronomy; two in archaeology; six in biology; five in the natural sciences; eight in earth science; five in nuclear physics; seven in mathematical machines; seven in aerodynamics; and seven in optics, heat and electronics.

The projects included are extracted from the monthly articles in *Scientific American* conducted by the author. Those familiar with this monthly journal will realize that a better source of projects is not available anywhere.

Use of color would have made the book more attractive. However, the lack of color does not seriously affect the quality of the book. The diagrams included are well done and the illustrations included are excellent.

The book is written primarily for the "amateur scientist." It could be of interest to many high school students as well as adults. Since the areas considered are diverse, this book could be used by students in chemistry, physics, earth science, and biology.

It is the opinion of this reviewer that this book is an excellent source of projects for students with an interest in science. It should be available in every high school and college science library shelf.

J. BRYCE LOCKWOOD
Highland Park Junior College
Highland Park, Mich.

NAIVE SET THEORY, by Paul R. Halmos, *Professor of Mathematics, The University of Chicago*. Cloth. Pages vii+104. 23.5×15.5 cm. 1960. D. Van Nostrand Company, Inc., 120 Alexander Street, Princeton, New Jersey. Price $3.50.

The author makes no pretense to inclusive coverage in this text, but states that he plans to "tell the beginning student of advanced mathematics the basic set-theoretic facts of life." The style is unusually informal; one might well say that it is deceptively simple. If the reader is not careful, he will find he is in trouble because he did not clearly understand an earlier paragraph.

In the opinion of the reviewer, this would be a very fine text for a graduate course. Those who have had some introductory work with sets, as for example some of the material now proposed for "modern" mathematics courses in the secondary school, will find the early portions of the book a valuable extension of this elementary treatment. This would probably include the first eight chapters, perhaps a little more. In fact, some superior secondary school students might profit by reading a few chapters. At the nominal price, the book can well be added to a school or private library.

On page 4, the reviewer was puzzled as to why the set x, such that the father of x is Adam, contains Cain and Abel and nothing else. What about Seth, to say nothing of other sons and daughters mentioned in the fifth chapter of Genesis?

CECIL B. READ
University of Wichita

THE NUMBER STORY, by Herta Taussig Freitag, *Hollins College, Virginia* and Arthur H. Freitag, *Jefferson Senior High School, Roanoke, Virginia*. Paper. 76 p. 15×23 cm. 1960. National Council of Teachers of Mathematics, 1201 Sixteenth Street N. W., Washington 6, D. C. Price 85 cents.

This pamphlet includes a treatment of the concept of number, readable by

high school students for the most part and certainly of value to the secondary school or college teacher. The emphasis is on the historical development of the number concept but there is much more than this in the pamphlet. For example, the development is carried as far as hypercomplex numbers, continued fractions, although perhaps the greatest emphasis is on somewhat more elementary topics.

Much of the historical material is not new but could be found in standard histories of mathematics. Perhaps the unusual feature is in the combination of historical material with certain concepts in the number system. This treatment is not readily available in any single reference. As a result the pamphlet should be of considerable value to the high school or junior college library and would be helpful to many teachers. The only points with which this reviewer would take issue are relatively minor. On page 28 it might have been pointed out that the subtractive principle was not a portion of the Roman numeral system as originally developed but a much later contribution. On page 33 the statement about the first actual appearance of the symbol 0 for zero does not agree with that found in certain other references. One wonders how such a positive statement can be made. On pages 54 and 55 one notes the omission (except for a rather brief discussion of seven) of tests for divisibility by seven, eleven, or thirteen. Since these are available, it might have been valuable to have included them in the discussion. On page 69 one wonders why the equation $e^{i\pi}+1=0$ ". . . combines the most important symbols of mathematics . . . ." Who determines what are the most important symbols? Why is + more important than − ? Are these symbols more important than, for example, the summation symbol or the integral sign or the factorial symbol?

CECIL B. READ
University of Wichita

A SHORT HISTORY OF SCIENTIFIC IDEAS TO 1900, by Charles Singer. Cloth. Pages xviii+525. 13×21.5 cm. 1959. Oxford University Press, 417 Fifth Avenue, New York 16, N. Y. Price $8.00.

The author points out that although this book is based on an earlier work published some twenty years ago, it is much more than a revision or a new edition, and hence has given a modified title.

The treatment could well be called elementary, a good high school student should be able to follow almost any chapter. For this reason, it would be a valuable addition to the secondary school library. It has a broad coverage of all phases of science, but as the title indicates, terminates (except for a few incidental references) with 1900. The reviewer found the book indeed interesting, and one which could be read continuously with profit; however, no doubt many readers will use it instead for seeking information about some particular individual or phase of scientific development.

The general theme or plan of the book is very interesting, with stress not alone on scientific facts, but on the philosophical implications. A few chapter titles may indicate this point of view: The Failure of Inspiration; The Failure of Knowledge; The Insurgent Century; The Mechanical World.

One minor typographical error was noted; in another place reference was made to Ezekiel xiii. 40 (page 186). The reviewer, curious as to the passage, discovered that in his Bible the thirteenth chapter of Ezekiel has only 23 verses (the reference may be to xxiii. 40).

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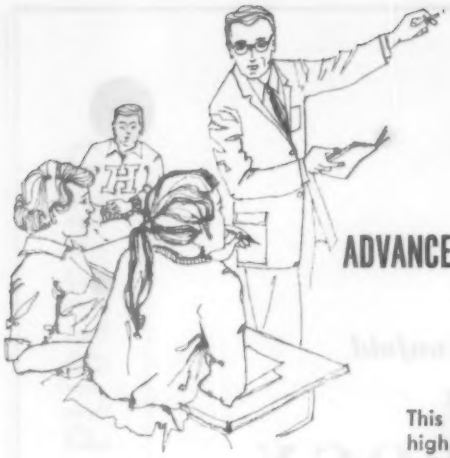

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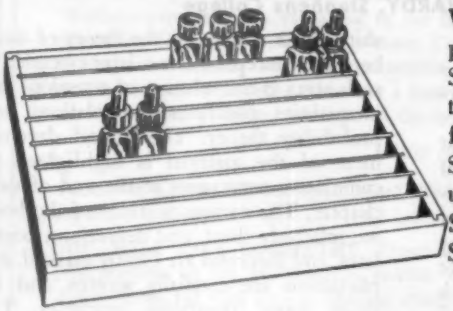

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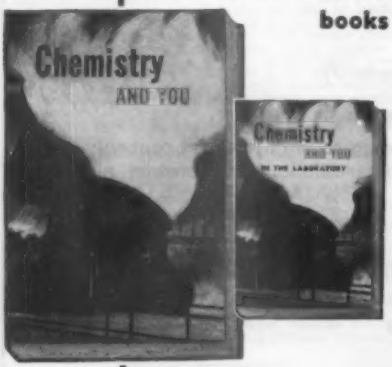

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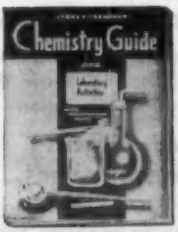

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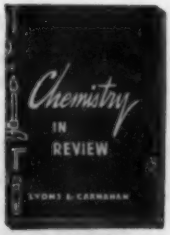

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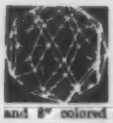

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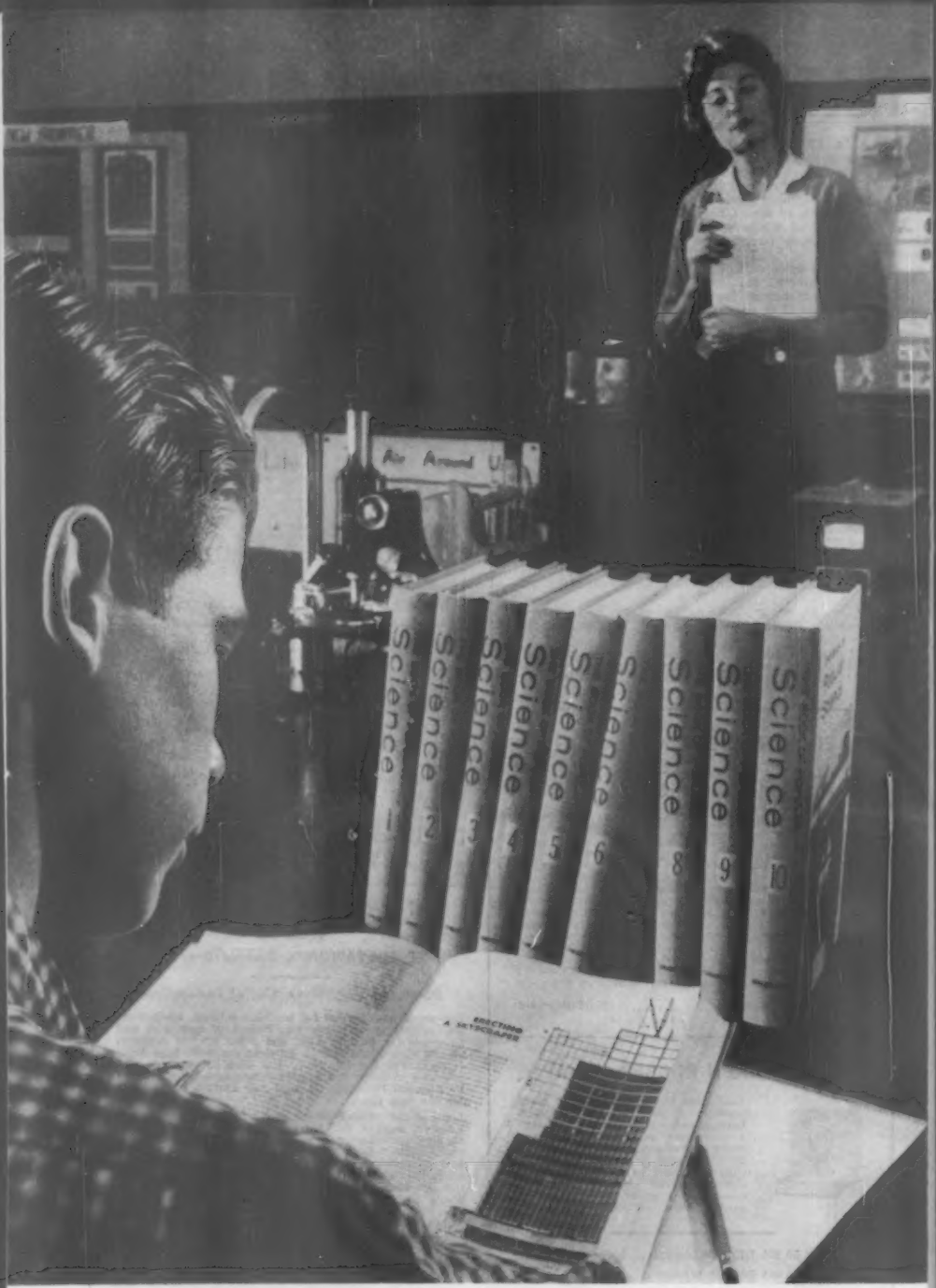

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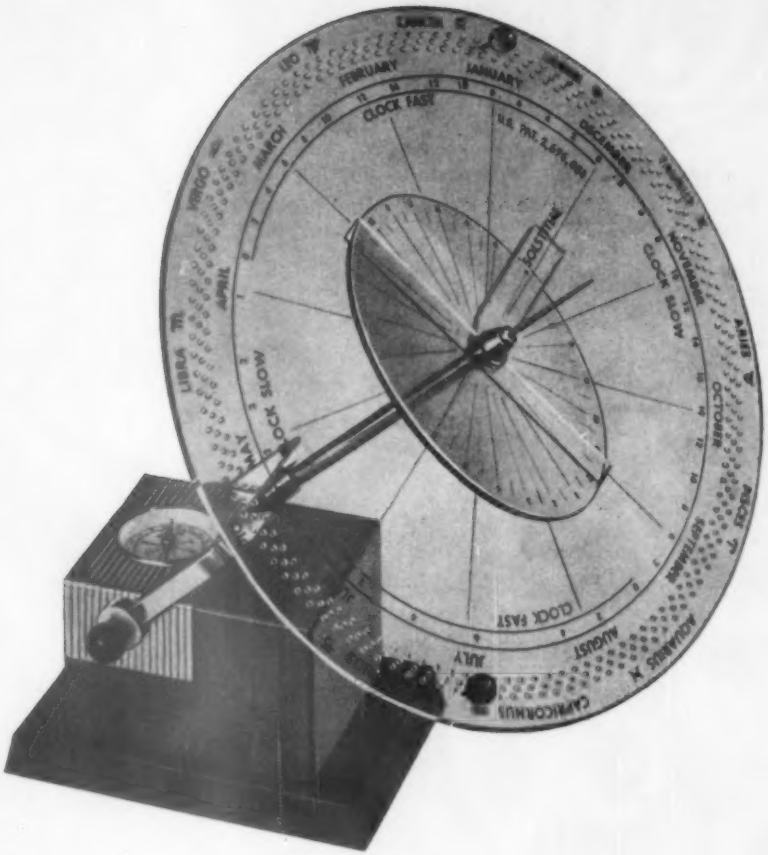

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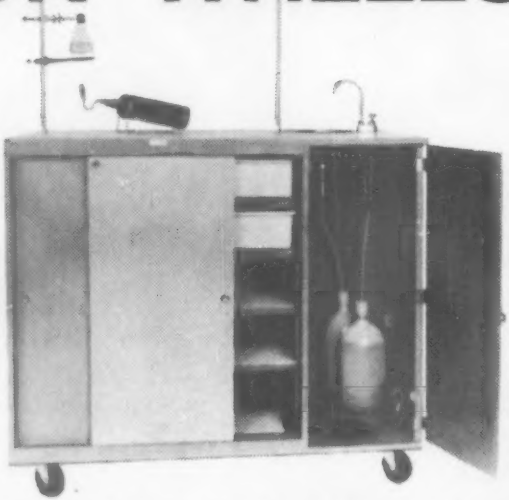

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